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THE PENIS OF THE CHLOROCYPHIDAE (ODONATA) AS
A GROUP-CHARACTER

By J. COWLEY, M.A.

[Read 18th November, 1936.]

WITH SIXTY TEXT-FIGURES.

THIS study was undertaken at the suggestion of Dr. F. F. Laidlaw in order to determine to what extent the penis in the family CHLOROCYPHIDAE (LIBELLAGINIDAE of authors) might afford group-characters; much of the material was kindly presented to me for my collection by Dr. Laidlaw, all species represented in the British Museum (Mr. Kimmings) and Cambridge University Museum (Mr. Kerrich) collections were examined, and Dr. F. C. Fraser supplied penes of *Chlorocypha asiatica* and *C. vittata*; to all of whom I wish to record my indebtedness, and in particular to Dr. Laidlaw who has given me much encouragement and criticism.

The penes were examined in the dried state, and proved to have complicated processes which are difficult to figure adequately as they are twisted and bent in various planes; they can be assigned to ten groups, in some of which (2, 4 and 8) specific differences are probably very slight and difficult to characterise, in other groups (3, 6 and 10) specific differences are well marked; but of the majority of species only one specimen was examined and no attempt was made to estimate any variability in specific details, and, as this study was only intended to give a preliminary grouping, no special effort was made to procure specimens of the rarer species, although it must be admitted that the penis of *Disparocypha* Ris would have been of great interest. Throughout I refrained from studying, either from specimens or in the literature, any other characters (venation, mesothoracic triangle, wing-patterns) on which groups of these insects have been established, in order to minimise any bias towards the accepted

groupings, although I realise that the penis should only be used as a group-character in conjunction with others. For reasons of convenience only, subspecies have been treated binomially as though they were species, no reflection on their taxonomic status being intended. Mr. Kimmins has descriptions of two new species in the press, Dr. Laidlaw of a new species and two new genera. Lest this study should appear before their descriptions are published, the names they are proposing have been omitted here. A general description of the penis of a *Chlorocyphid* follows:—

Internal and terminal folds present, the third segment normally developed, the apical lateral angles produced as a pair of processes which are probably homologous with the *ausseren Fäden* of Schmidt, 1915 (AGRIIDAE), the *lower penis lobes* of Kimmins, 1933 (*Umma*) and the *oberen Penisfäden* of May, 1935 (*Vestalis*-group), and are here termed the *lateral apical processes*; this pair of processes symmetrically disposed (constantly asymmetrical in certain genera of AGRIIDAE) and directed more or less cephalad and ventrad, frequently spirally twisted. Each lateral apical process may have the mesal and exterior surfaces differentiated into an *internal branch* directed more cephalad and an *external branch* directed more caudad or ventrad; the division into these branches generally somewhat distad to the apical lateral angles of the third segment, marking off an undivided *basal stem* (see fig. 55 D), but not always evident when the external branch is not well developed. These internal and external branches may possibly be homologous with the *inner* and *outer branches of the lower penis lobes* found by Kimmins (1933) in *Umma* (cf. *U. cincta*), to which the penis of some forms of *Rhinocypha* bear quite a noticeable superficial resemblance (e.g. figs. 53–55); the homology of the external branch with the *Zahn*, *Zapfen* or *Haken* of the *oberen Penisfäden* in the *Vestalis*-group (May, 1935) is perhaps rather more problematical; indeed, these questions of homology of structures which may only be developed in diverse groups (perhaps phylogenetically specialised) must remain in doubt until a more complete knowledge of the general phylogeny and penes of the Zygoptera is available. There are no traces of the *inneren Fäden* of Schmidt, 1915, *upper penis lobes* of Kimmins, 1933, *unteren Penisfäden* of May, 1935, here termed the *median apical processes*. (An alternative scheme would be to homologise the internal branch with the median apical process, the external branch with the lateral apical process of the AGRIIDAE, supposing the division between the two branches to have moved more and more basad and finally to have entirely separated basally as in the typical Agriid condition; but I consider this explanation to be much less probable, for not only do similar branches of the lateral apical process appear to be present in *Umma*, which has the median apical processes also, but in addition the condition in *Chlorocypha*, in which the two branches have become separated, is entirely different from that of the AGRIIDAE, for in the former the internal branch comes to arise *subapically* from the *dorsal surface* of the third segment, whereas in the latter the median apical process is an *apical continuation* of the *margin* of the segment itself.) Spines and hairs on the shaft of the penis were not studied, but generally there are a few very short spines which are scarcely visible.

The chief group-characters are provided by the external and internal branches of the lateral apical processes; variations in the form of the internal and terminal folds and the third segment are slight and do not lend themselves to this purpose, the only exception to the general uniformity found being the excised base of the third segment in *Rhinocypha* sp. (fig. 29 E). It is assumed here that the forms with an undifferentiated external branch are the more primitive,

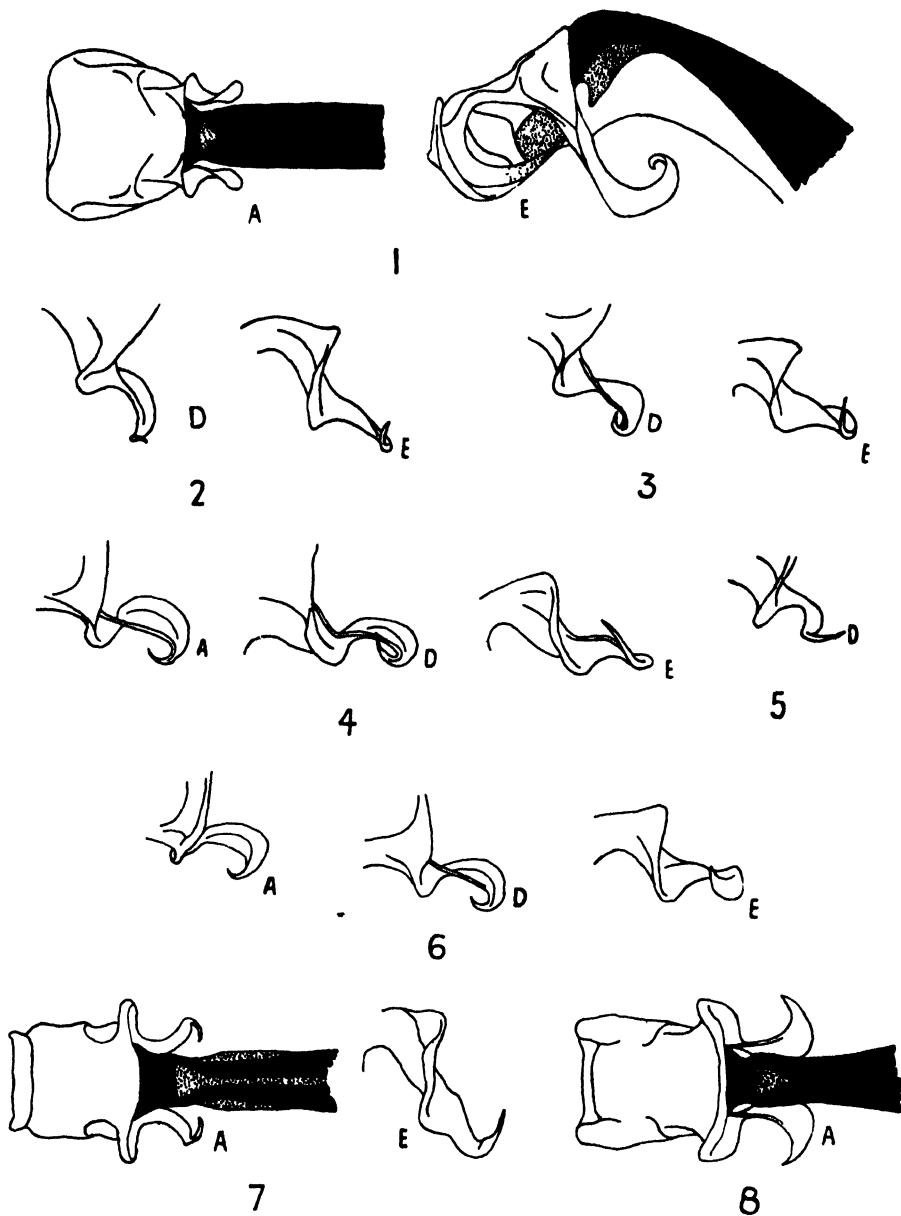


FIG. 1. (*Chlorocypha*) *vittata* Selys. (F.C.F.)
 2. *Libellago hyalina* Selys. Baram, Sarawak, ix.1920. (J.C.)
 3. *L. indica* Fraser. Fraserpét, Coorg, Indiá, 25.x.1924. (J.C.)
 4. *L. finalis* Selys. Kandy, Ceylon, 11.x.1924. (J.C.)
 5. *L. semiopaca* Selys. Kuala Tahan, Pahang, 9.xi.1921, F. N. Chasen. (J.C.)
 6. *L. aurantiaca* Selys. Phachaung, Tenasserim, 16.ii.1927. (J.C.)
 7. *L. greeni* Laidlaw. PARATYPE; Kandy, Cent. Province, Ceylon, 1.xii.1909, E. E. Green. (B.M.)
 8. *L. bisignata* McLachlan. HOLOTYPE; Tondano, Menado, Wallace. Saunders coll. (B.M.)

those with elaborated branches the more specialised and recent. If this is so, one may trace lines of development from Group 2, which includes *Libellago* and some *Rhinocypha* species (the latter perhaps a heterogeneous assemblage of primitive forms) through Groups 3 (*Calocypha*) and 4 to Group 7, with Groups 5 and 6 (*Rhinoneura*) as more specialised offshoots from near the apex of this line; another line would be a development of Group 8 from Group 2. Group 1 (*Chlorocypha vittata*) may perhaps be the most primitive form in which the external branch is undeveloped and the internal branch long and simple, while Group 9 (*Chlorocypha asiatica*), in my opinion, is a development of Group 8, the internal branch having been lost and the external branch further specialised; it is worthy of note that these are the two anomalous Asiatic species of *Chlorocypha*, which Dr. Laidlaw proposes on other grounds to place in two new genera, which course is supported by the penes being markedly different from each other and from those of the African species of *Chlorocypha*. Group 10 (*Chlorocypha*) stands apart as the most specialised group in which the external branch reaches its maximum development and the point of divergence of the branches has passed basad until there is no longer any basal stem and the internal branch arises from the dorsal surface of the third segment subapically (there is throughout the groups a tendency for the mesal margin of the basal stem to arise in this way); this group cannot readily be derived directly from any of the others. The characterisation of the groups follows; so far as possible the forms in each group have been arranged in the order of increasing specialisation of the penis. (A much less probable alternative would be to derive the penis of Group 8 from some *Umma*-like form by the loss of the median apical processes, and then by reduction of the branches back to Groups 1 and 2, and also by further specialisation to Groups 9 and 10. This hypothesis leads to unnecessary complications, in contrast to the comparative simplicity of that outlined above. This is not the place to develop phylogenetic schemes based on a single organ.)

Group 1 (Gen. nov., Laidlaw; fig. 1). External branch of lateral apical process not evident, internal branch simple, long: *Chlorocypha vittata* Selys (figs. 1 A, E). On venational grounds Dr. Laidlaw is erecting a new genus for this species.

Group 2 (*Libellago*, and *Rhinocypha* part; figs. 2-17). External branch of lateral apical process but little developed, not more than a swelling or ridge on the basal stem, the internal branch moderately long, generally lanceolate and twisted, in the higher forms tending to be somewhat dilated subapically: *Libellago hyalina* Selys (figs. 2 D, E), *L. indica* Fraser (figs. 3 D, E), *L. finalis* Selys (figs. 4 A, D, E), *L. semiopaca* Selys (fig. 5 D), *L. aurantiaca* Selys (figs. 6 A, D, E), *L. greeni* Laidlaw (figs. 7 A, E), *L. bisignata* McLachlan (fig. 8 A), *L. snellemanni* Selys (figs. 9 D, E); *L. stictica* Selys, *phaethon* Laidlaw, *mima* Lieftinck and *lineata* Burmeister similar to *snellemanni*; *L. stigmatizans* Selys (cf. Kennedy, 1920, figs. 80, 81), *L. xanthociana* Selys (figs. 10 A, E), *L. rufescens* Selys (fig. 11 D), *Rhinocypha unimaculata* Selys (figs. 12 A, D, E), *R. terminata* Selys (figs. 13 A, D, E, J), *R. iridea* Selys (figs. 14 D, F), *R. ignipennis* Selys (figs. 15 A, D), *R. trimaculata* Selys (figs. 16 A, D, E, G), *R. paganstecheri* Förster (figs. 17 A, B, D, E, J). It may be doubted whether all these heterogeneous *Rhinocypha* species belong to this group, but they appear to agree better with the majority of this group than any other; the *Libellago* species studied undoubtedly all fall into one group.

Group 3 (*Calocypha*; figs. 18, 19). External branch of lateral apical process but little developed, internal branch shorter and broader, scarcely twisted,

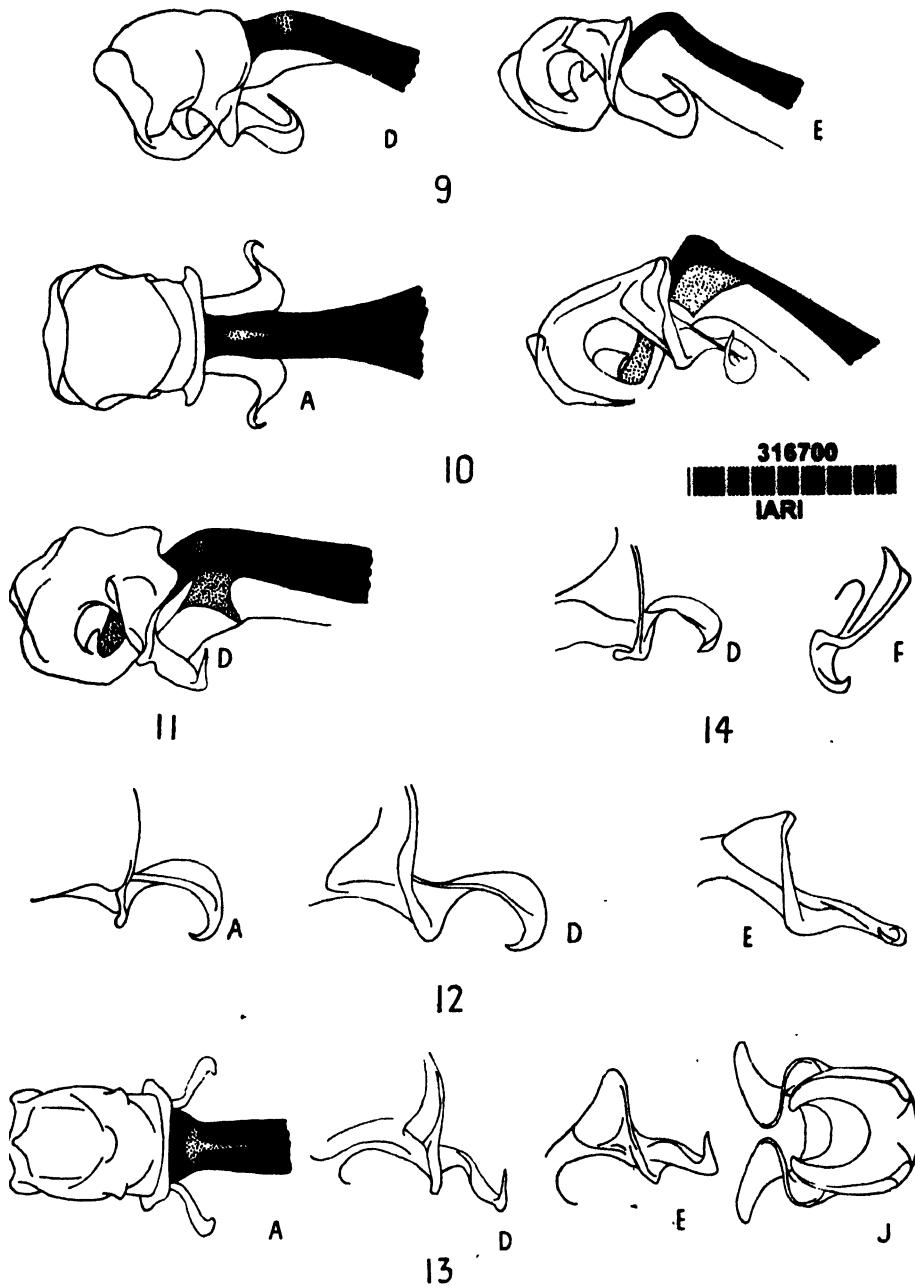


FIG. 9. *L. snellemanni* Selys. Benkoelen Distr., Sumatra, C. J. Brooks. (B.M.)
 10. *L. xanthocyanus* Selys. Celebes. (B.M.)
 11. *L. rufescens* Selys. HOLOTYPE; Celebes or Mindanao. Saunders coll. (B.M.)
 12. *Rhinocypha unimaculata* Selys. Simla, India. (J.C.)
 13. *R. terminata* Selys. Amboina, E. Indies, F. Muir. (U.M.Z.C.)
 14. *R. iridea* Selys. Maymyo, Upper Burma, 16.xi.1924. (J.C.)

the apex not markedly pointed: *Calocypha petiolata* Selys (figs. 18 A, E, F), *C. landlawi* Fraser (figs. 19 A, E). This group might perhaps be included in 2 as a subgroup.

Group 4 (*Rhinocypha* part; figs. 20-28). External branch of lateral apical process projecting laterally as a rounded expansion, internal branch generally short, fairly broad, sometimes with a subapical mesal expansion: *Rhinocypha frontalis* Selys (fig. 20 A); *R. colorata* Selys, *albistigma* Selys and *monochroa* Selys similar to *frontalis*; *R. spinifer* Laidlaw (figs. 21 A, D), *R. bisignata* Selys (fig. 22 D), *R. humeralis* Selys (figs. 23 A, D, E), *R. moultoni* Laidlaw (fig. 24 D), *R. perforata* Percheron (figs. 25 D, H), *R. semitincta* Selys (figs. 26 A, E), *R. tincta* Rambur (fig. 27 D), *R. limbata* Selys (figs. 28 A, D, E); perhaps also *R. eximia* Selys (cf. Kennedy, 1920, figs. 78, 79).

Group 5 (*Rhinocypha* part; fig. 29). External branch of lateral apical process projecting laterally as a rounded expansion, internal branch simple, long, the base of the third segment excised to form a pair of lateral lobes directed caudo-dorsad: *Rhinocypha* sp. n. Kimmins, near *stygia* Förster (fig. 29 E).

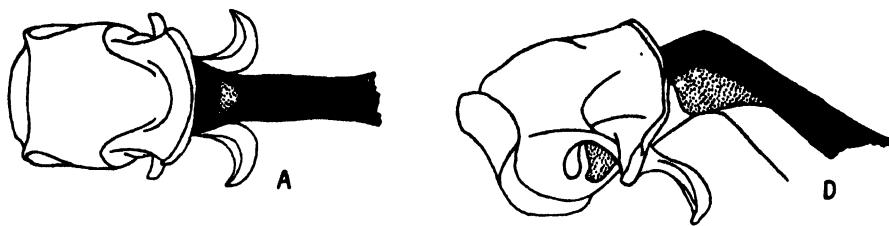
Group 6 (*Rhinoneura*; figs. 30, 31). External branch of lateral apical process projecting laterally as a rounded expansion, internal branch broad, moderately long, directed laterad, the apex expanded and turned ventrad: *Rhinoneura villosipes* Laidlaw (figs. 30 A, E), *Rhinoneura* sp. n. Kimmins (figs. 31 A, C, E).

Group 7 (*Rhinocypha* part; figs. 32-37). External branch of lateral apical process projecting laterally as a rounded expansion (scarcely so in *R. anisoptera*), internal branch with the apex forming a rounded plate turned dorsad: *Rhinocypha anisoptera* Selys (figs. 32 A, D, F), *R. cucullata* Selys (figs. 33 A, D, E, H), *R. aurofulgens* Laidlaw (figs. 34 A, D, E, F), *R. selysi* Krüger (figs. 35 A, D, F), *Rhinocypha* sp. n. Laidlaw (figs. 36 A, E), *R. heterostigma* Rambur (figs. 37 A, D, E).

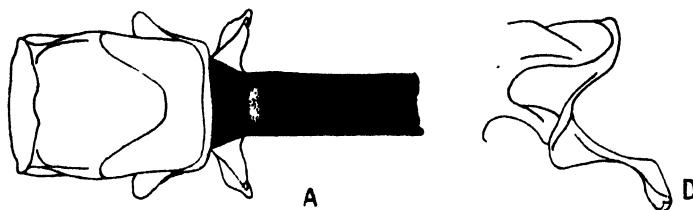
Group 8 (*Rhinocypha* part; figs. 38-55). External branch of lateral apical process projecting caudad, ventrally quite distinct from the stem and tending to be marked off from it by an excision, internal branch short, simple, pointed: *Rhinocypha bifasciata* Selys (figs. 38 A, D, E), *R. hemihyalina* Fraser (figs. 39 A, E), *R. cuneata* Selys (figs. 40 A, E), *R. fenestrella* Rambur (figs. 41 A, D, E), *R. fulgipennis* Guérin (figs. 42 A, D), *R. fenestrata* Rambur (figs. 43 A, D, E), *R. beesonii* Fraser (figs. 44 A, D, E), *R. biforata* Selys (figs. 45 A, D, E), *R. spuria* Selys (figs. 46 A, D, E, G), *R. bifenestrata* Fraser (figs. 47 A, D, E, F), *R. hilaryae* Fraser (figs. 48 A, D, E, J, K), *R. mariae* Lieftinck (figs. 49 A, D), *R. quadruplicata* Selys (figs. 50 A, D, E; cf. Schmidt, 1915, pl. 11, fig. 49). *R. immaculata* Selys (figs. 51 A, D), *R. biseriata* Selys (fig. 52 D), *R. anambae* Laidlaw (similar to *biseriata*), *R. angusta* Selys (fig. 53 D; cf. Kennedy, 1920, figs. 76, 77), *R. delimbata* Selys (fig. 54 D), *R. trifasciata* Selys (figs. 55 A, D, E).

Group 9 (gen. nov., Laidlaw; fig. 56). External branch of lateral apical process long, directed caudad and somewhat dorsad, notched as in the previous group, internal branch apparently absent: *Chlorocypha asiatica* Selys (figs. 56 A, B, D, E). On venational grounds Dr. Laidlaw is erecting a new genus for this species.

Group 10 (*Chlorocypha*; figs. 57-60). External branch of lateral apical process large, strap-shaped, extending markedly dorsad, basal stem of the process absent, internal branch arising from the dorsal surface of segment 3 subapically, long, the apex more or less expanded and sometimes turned ventrad: *Chlorocypha selysi* Karsch (figs. 57 A, E, J); *C. rubida* Selys, *curta* Selys and



15



A

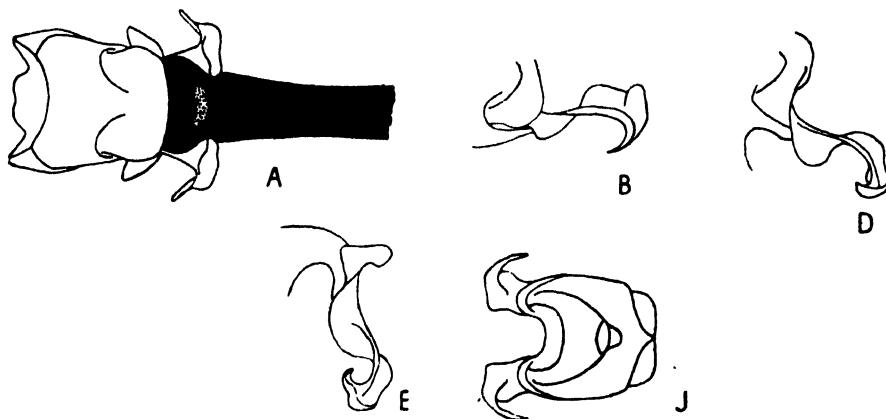
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E

G

16



A

B

D

E

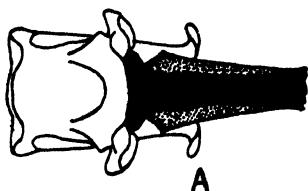
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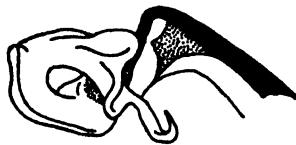
FIG. 15. *R. ignipennis* Selys. Shillong, Assam, H. M. Parish. (B.M.)

16. *R. trimaculata* Selys. Khasi Hills, Assam. (J.C.)

17. *R. pagenstecheri* Förster. Lombok, 1,500 ft., v.1896, Everett. (U.M.Z.C.)



A

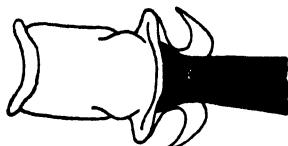


E



F

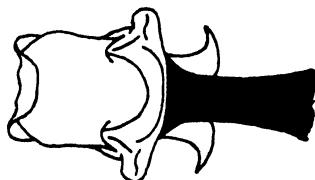
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A



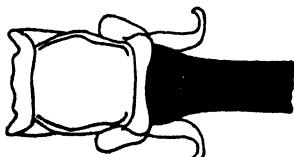
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A

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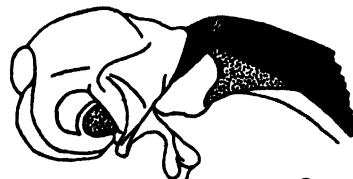


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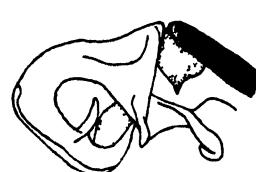
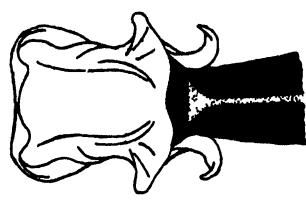
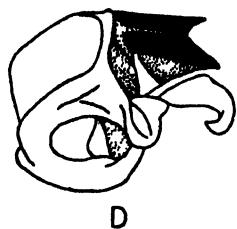
FIG. 18. *Calocypha petiolata* Selys. Bengkajang, nr. Singkawang, W. Borneo, 21.iv.1932, Coomans de Ruiter. (J.C.)

19. *C. laidlawi* Fraser. Sampaji, Coorg, India, 8.xii.1924, F. C. Fraser. (B.M.)

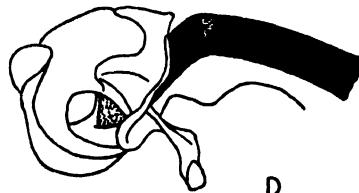
20. *Rhinocypha frontalis* Selys. Shortland Is. (B.M.)

21. *R. spinifer* Laidlaw. R. Koyan, 2,500 ft., Mt. Dulit, Sarawak, 17.xi.1932, B. M. Hobby & A. W. Moore. (B.M.)

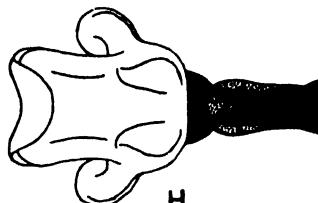
22. *R. bisignata* Selys. Khandala, India, 7.iv.1920, F. C. Fraser. (B.M.)



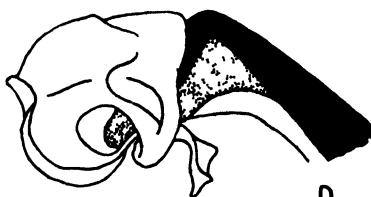
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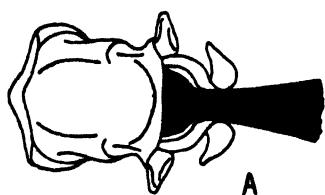
FIG. 23. *R. humeralis* Selys. Balaboe. (J.C.)

24. *R. moultoni* Laidlaw. HOLOTYPE; Kinabalu, Borneo, 1.x.1913, J. C. Moulton. (B.M.)

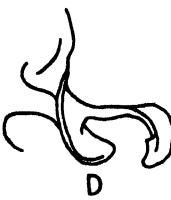
25. *R. perforata* Percheron. Mt. Wuchi, Hainan, 21.v.1903. (B.M.)

26. *R. semitincta* Selys. Gizo Is., A. S. Meek. (J.C.)

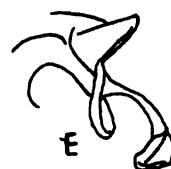
27. *R. tincta* Rambur. New Guinea, Wallace. (B.M.)



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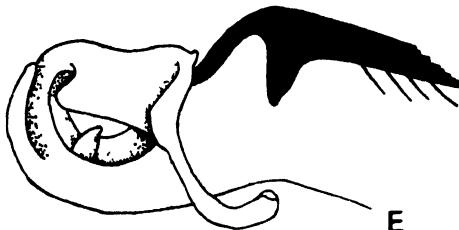


D



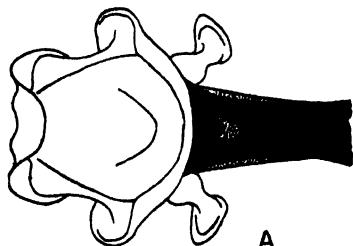
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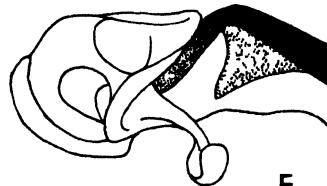


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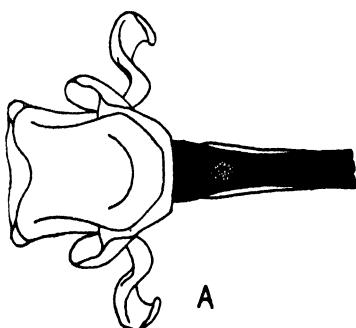


A



E

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A



C



E

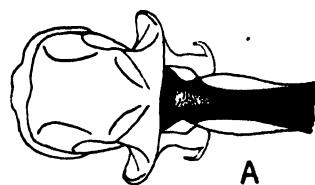
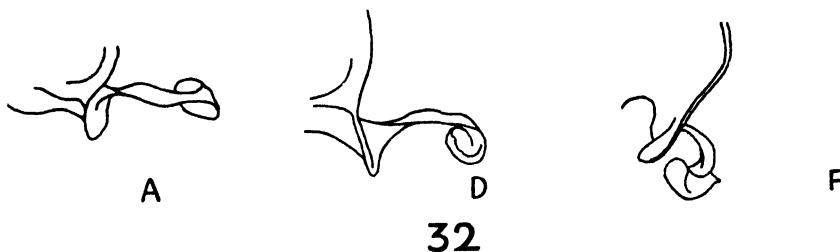
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FIG. 28. *R. limbata* Selys. PARATYPE of *R. inas* Laidlaw; Gunong Inas, Malay Peninsula Skeat Expedition. (U.M.Z.C.)

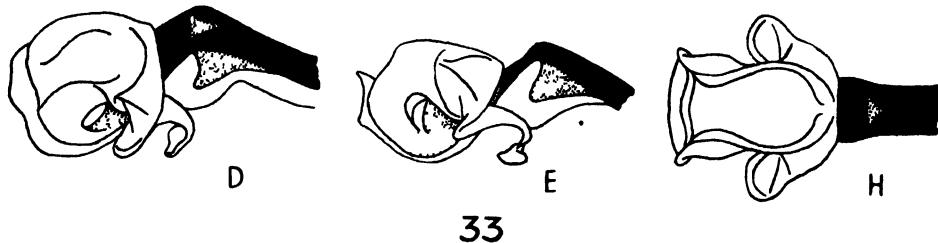
29. *Rhinocypa* sp. n. Kimmins. PARATYPE; Dulit Trail, Mt. Dulit, Sarawak 10.viii.1932, B. M. Hobby & A. W. Moore. (B.M.)

30. *Rhinoneura villosipes* Laidlaw. HOLOTYPE; Kinabalu, Borneo, 6.ix.1913, J. C Moulton. (B.M.)

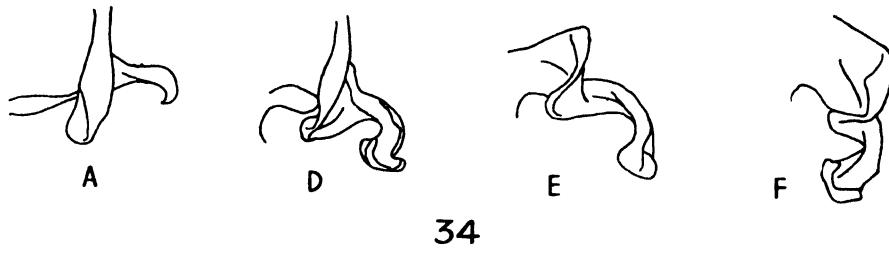
31. *Rhinoneura* sp. n. Kimmins. HOLOTYPE; Mt. Dulit, 4,000 ft., Sarawak, 22.x.1932 B. M. Hobby & A. W. Moore. (B.M.)



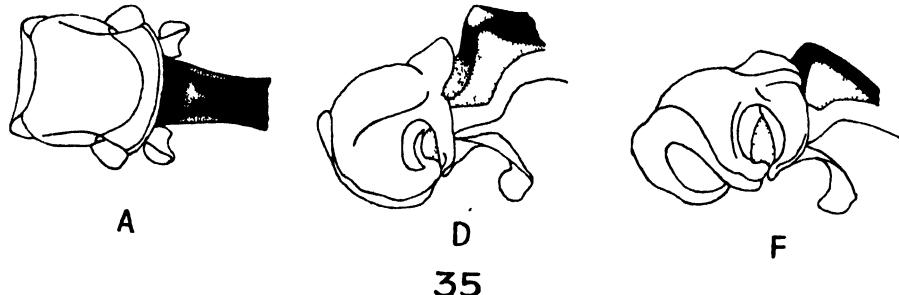
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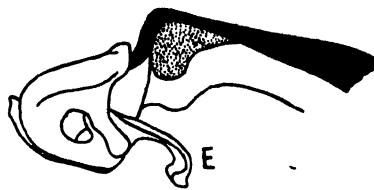
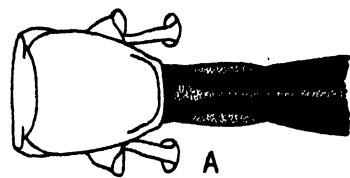
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FIG. 32. *Rhinocypha anisoptera* Selys. Malang, E. Java, ix-x.1929, S.O. (J.C.)

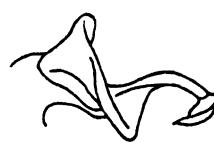
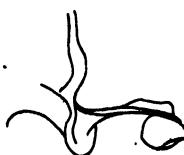
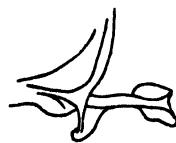
33. *R. cucullata* Selys. Madalam, Sarawak, 15.ii., H. W. Smith. (J.C.)

34. *R. aurofulgens* Laidlaw. Lewpin Aga House, 7.x.1920. (J.C.)

35. *R. selysi* Krüger. Setinjak, Philippine Is. (! recte Sumatra), 1,800 ft. (B.M.)



36



A

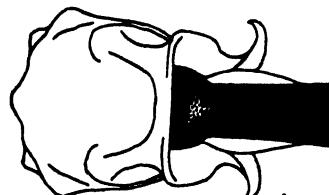
D

E

37



E



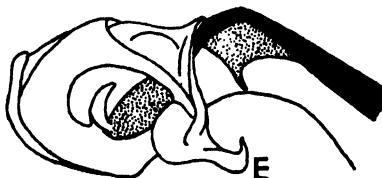
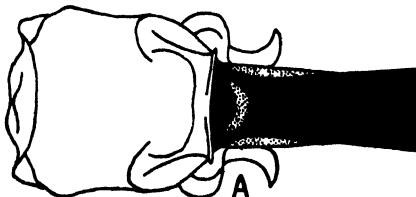
D

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E

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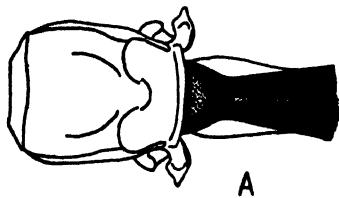
FIG. 36. *Rhinocypha* sp. n. Laidlaw. HOLOTYPE; Gunong Kledang, Perak, 2,646 ft., xi.1916. (B.M.)

37. *R. heterostigma* Rambur. Batorraden, Java (?), 18.xii.1927. (J.C.)

38. *R. bifasciata* Selys. Mungpoo, Darjeeling Distr., 4,000 ft., India, 19.xi.1924. (J.C.)

39. *R. hemihyalina* Fraser. HOLOTYPE; Khasi Hills, Shillong, 16.x.1919, Fletcher. (B.M.)

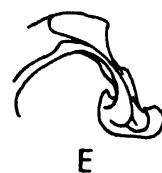
40. *R. cuneata* Selys. Sikkim. Crowley bequest. (B.M.)



A

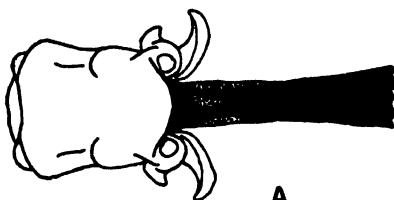


D

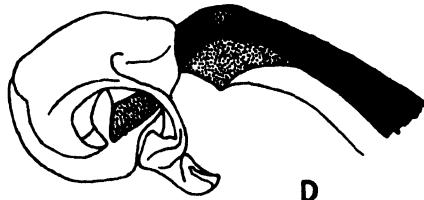


E

41

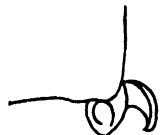


A



D

42



A



D



E

43



A



D



E

44



A



D



E

45

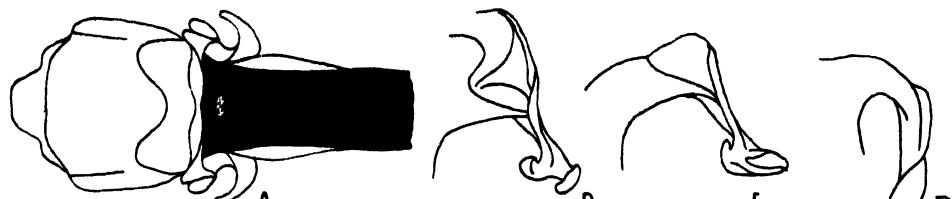
FIG. 41. *R. fenestrella* Rambur. Malay Peninsula, Skeat Expedition. (U.M.Z.C.)

42. *R. fulgipennis* Guérin. Daban, Phanrang Prov., S. Annam, 650 ft., 1918, Malcolm A. Smith, C. Boden Kloss. (B.M.)

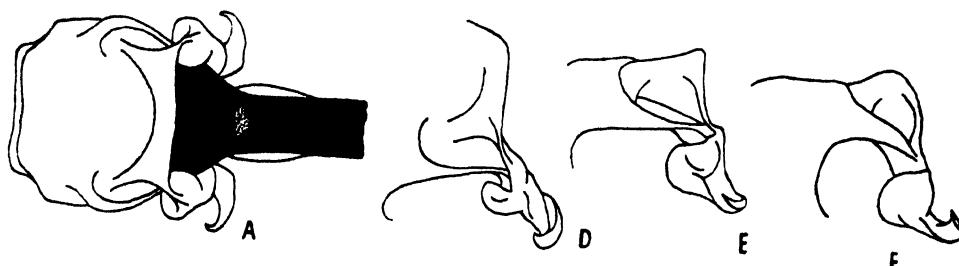
43. *R. fenestrata* Rambur. Ranu Lamongan, Klakah, E. Java, x-xi.1928, A. Thiemann. (J.C.)

44. *R. beesonii* Fraser. Mergui, Lower Burma, Bott. (J.C.)

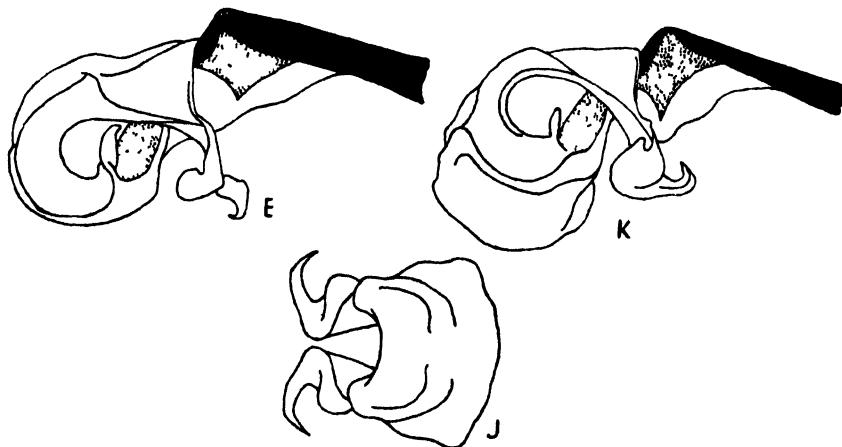
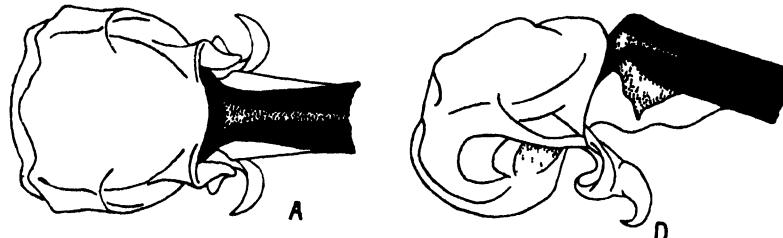
45. *R. biforata* Selys. Catchment area nr. Jitra, India, 10.iv.1928. (J.C.)



46



47

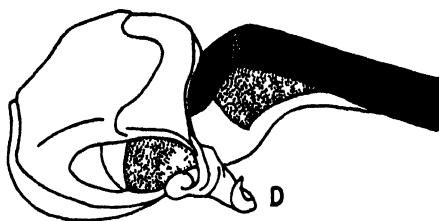
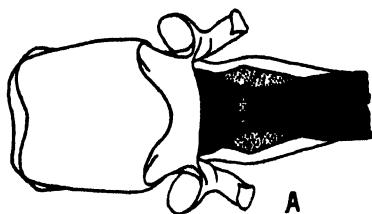


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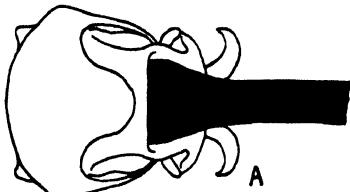
FIG. 46. *R. spuria* Selys. Khasi Hills, Assam. (J.C.)

47. *R. bifenestrata* Fraser. Moungpoo, Darjeeling Distr., India, 25-29.v.1927. (J.C.)

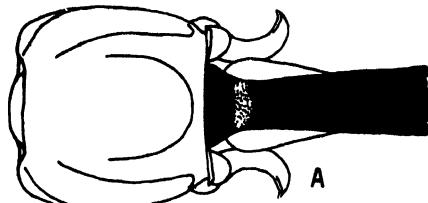
48. *R. hilaryae* Fraser. PARATYPE; Maymyo, Upper Burma, 19.vi.1924, F. Wall. (J.C.)



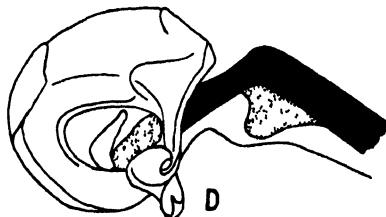
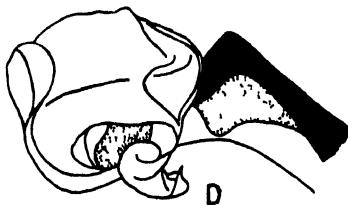
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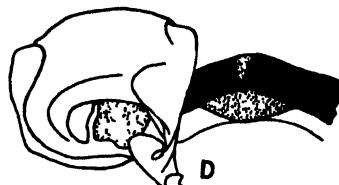
FIG. 49. *R. mariae* Lieftinck. Wai Panas, Ranau See, S. Sumatra, 4.ii.1929, A. Thienemann. (B.M.)

50. *R. quadrrimaculata* Selys. Cherrapunji, Khasi Hills, Assam. (J.C.)

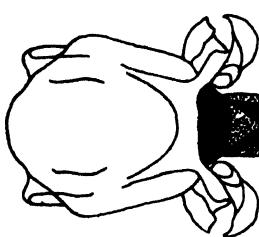
51. *R. immaculata* Selys. Cherrapunji, 4,900 ft., Assam. (L.M.)

52. *R. biseriata* Selys. Kinabalu, Borneo. (B.M.)

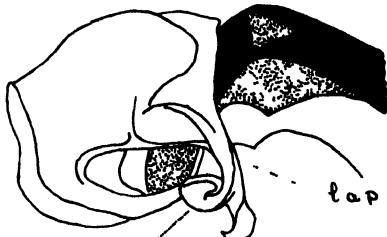
53. *R. angusta* Selys. Setinjak, Sumatra, 1,800 ft., i.1898, Ericson leg. (B.M.)



54



A

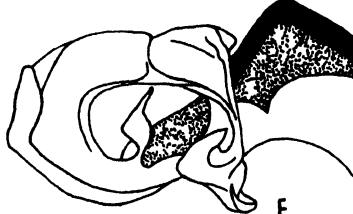


l.a.p.

e.b.

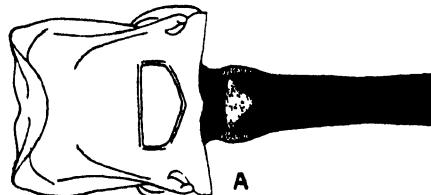
D

i.b.

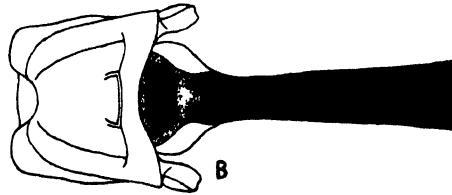


E

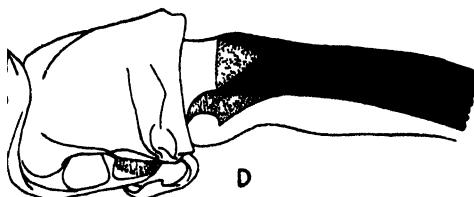
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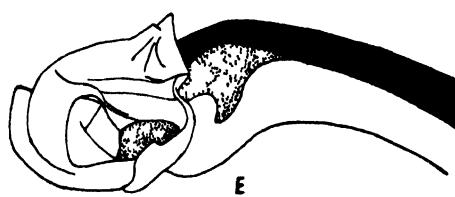
A



B



D



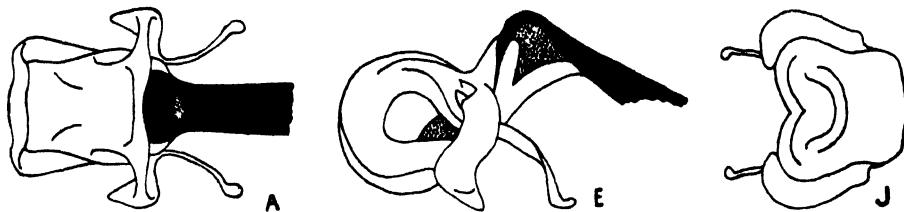
E

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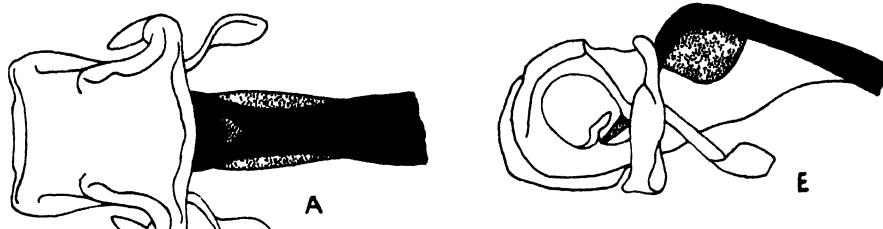
FIG. 54. *R. delimbata* Selys. Basin of Fleuve Rouge, Thai-Nien, Tonkin, 19.III.1924, H. Stevens. (B.M.)

55. *R. trifasciata* Selys. N. India. (B.M.). l.a.p.: basal stem of lateral apical process; i.b.: internal branch; e.b.: external branch.

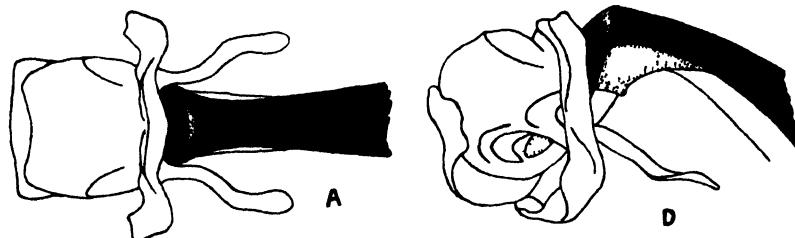
56. (*Chlorocypha*) *asiatica* Selys. (F.C.F.)



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59



60

FIG. 57. *Chlorocypha eelysi* Karsch. Santa Isabel, Fernando Po, 24.iii.1904. (B.M.)

58. *C. jejuna* Baumann. Chirinda For., Gazaland, 3,600 ft., 17.x.1905, G. A. K. Marshall. (B.M.)

59. *C. dispar* Beauvois. Edijar, Ashanti, E. Coast, 31.i.1913, J. J. S. (B.M.)

60. *C. caligata* Selys. Pietermaritzburg, Natal. (J.C.)

glaucifrons Sjöstedt similar to *selysi*; *Chlorocypha* sp. (Schmidt, 1915, pl. 11, fig. 48), *C. jejuna* Baumann (figs. 58 A, E), *C. dispar* Beauvois (figs. 59 A, D), *C. caligata* Selys (figs. 60 A, D, E; cf. Kennedy, 1920, figs. 74, 75).

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KIMMINS, D. E., 1933, The form of the penis as a group-character in the genus *Umma*, Kirby (Odonata). *Stylops*, **2** : 140-144, 14 figs.

MAY, E., 1935, Über die Genera *Vestalis* Selys, *Vestinus* Kennedy und *Vestalaria* n.g. *Senckenbergiana*, **17** : 207-218, 22 figs.

SCHMIDT, E., 1915, Vergleichende Morphologie des zweiten und dritten Abdominal-segments bei männlichen Libellen. *Zool. Jahrb., (Anat.)*, **39** : 87-200, 24 figs., 3 pls.

DESCRIPTIONS OF FIGURES.

Penes of CHLOROCYPHIDAE, from camera lucida drawings by myself (except fig. 29 by Mr. D. E. Kimmins). When only part of the penis is figured, it is the whole of the left lateral apical process and part of the apex of the third segment. Although part of the right lateral apical process may be visible in lateral and semilateral views, it is omitted for greater clarity. The letters after the figure-numbers indicate the following views :—

A. ventral.	F. left latero-caudo-ventral.
B. cephalo-ventral.	G. left latero-caudal.
C. left latero-cephalo-ventral.	H. caudo-ventral.
D. left latero-ventral.	J. caudal.
E. left lateral.	K. left latero-dorso-caudal.

The collections containing the specimens figured are indicated by abbreviations : B.M. (British Museum, Natural History), F.C.F. (collection of Dr. F. C. Fraser), I.M. (Indian Museum, Calcutta), J.C. (collection of the author), U.M.Z.C. (University Museum of Zoology, Cambridge).

Postscript.—The descriptions of the new species mentioned above have been published while this paper was in the press :

Rhinocypha cognata Kimmins, 1936, *J.F.M.S. Mus.*, **18** : 84, fig. 8 (Sarawak).
Rhinoneura caerulea Kimmins, 1936, *loc. cit.* : 79, fig. 6 A, C (Sarawak).
Rhinocypha pelops Laidlaw, 1936, *loc. cit.* : 60, pl. I, fig. 1 (Perak).

A REVISION OF THE MALAYAN SPECIES OF *CELASTRINA*
(LEPIDOPTERA: LYCAENIDAE)

By A. STEVEN CORBET, D.Sc., Ph.D., F.I.C.

[Read 18th November, 1936.]

WITH 12 FIGURES.

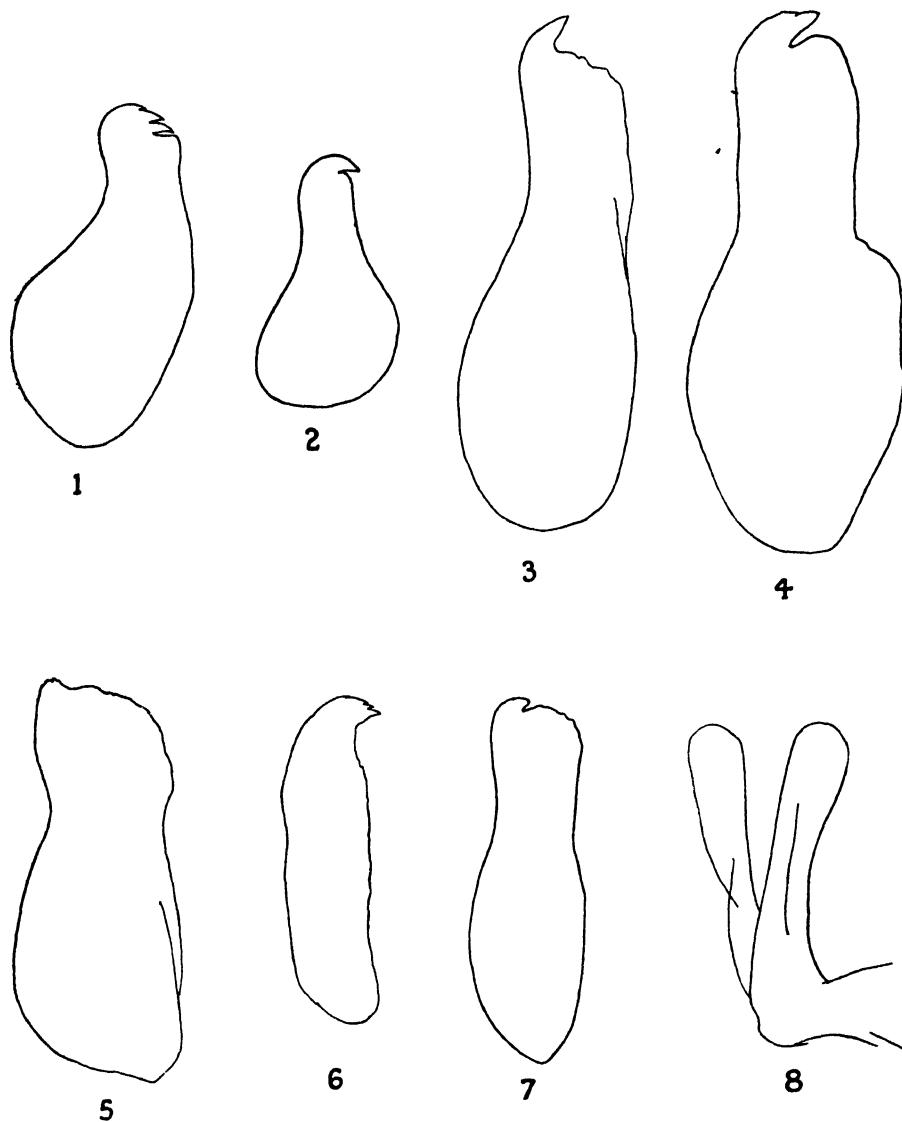
THE great similarity between species in the genus *Celastrina* makes identification a matter of some difficulty and this, doubtless, is the reason why the group has been studied so little. Chapman (1909, *Proc. zool. Soc. Lond.*, 1909 : 419-476) first investigated the male genitalia of the *Celastrina* species and his paper contains excellent photographs of the genital armature of all forms known to him. Later, Fruhstorfer (1917, *Arch. Naturgesch.*, 82 (A) (1) : 1-42) examined the genus on the basis of the genitalia, and in his monograph (1922, *in Seitz, Grossschmett. Erde*, 9 : 858-877) he succeeded largely in reducing chaos to order; as was almost inevitable at this stage, however, many of Fruhstorfer's collective species were not single entities and a number of subspecies were allocated incorrectly. Recently, important papers on the Javanese *Lycaenopsini* have appeared (Toxopeus, 1927, *Tijd. Ent.*, 70 : 232-302; 1928, *Tijd. Ent.*, 71 : 179-265; 1935, *Ent. Med. Ned. Indië*, 1 : 68-72) in which the Javanese forms are examined in very thorough fashion and the question of the collective species occurring in Malaysia is considered in some detail. Keys for the separation of the Indian species are given by Evans. (1932, *Ident. Indian Butt.* : 221-225). The *Lycaenopsini* genera have been revised by myself (1936, *Proc. R. ent. Soc. Lond.* (B), 5 : 185-186).

In view of the great similarity in markings between many species of *Celastrina*, the differences often found in the structure of the male claspers are quite striking and the genitalia constitute a reliable means of separating closely-allied species. The claspers of all Malayan species likely to present any difficulty in determination are shown in figs. 1-10. When present, the androconial scales often differ from one species to another but, usually, these differences are slight, although the wedge-shaped scales of *C. musina* are very distinctive.

The results of the genitalia examinations carried out in the course of the work described in this paper are in accord with those of previous workers, except that Fruhstorfer's description of the male genitalia of *C. moultoni* (Seitz, *Grossschmett. Erde*, 9 : 867) is rather misleading.

With all Malaysian *Celastrina* species, the trend of the geographical variation is the same; Malayan forms are darkest in colour, they have the broadest black bordering, the most generous black dusting and the heaviest underside markings. The Javanese races are much lighter in all respects, having the most extensive white areas and much reduced black bordering. The intermediate Sumatran forms approach more nearly to the Malayan races. Where the forms from East and West Java differ, those from the drier eastern part of the island are lighter.

Although the Bornean *Celastrina* species are by no means as well known as those of the rest of Malaysia, the Bornean representatives of species occurring in Malaya, Sumatra and Java are usually dark and heavily marked much as in the Malayan races.



FIGS. 1-8.—Male clasper of: (1) *Celastrina camenae pendleburyi*, (2) *C. ceyx tanarata*, (3) *C. dilecta briga*, (4) *C. singalensis xanthippe*, (5) *C. placidula irenae*, (6) *C. lavenularis isabella*, (7) *C. pellecebra cyma*, (8) *C. moultoni*.

Key for the separation of the Malaysian species of *Celastrina*.

1 (4). F cell shorter than half length of wing. Both sexes white with black bordering to both wings, only bases blue dusted. ♂ without androconia.

quadriplaga group.

2 (3). UnF discal spots broad and prominent: upH distal border at least 2 mm. broad *quadriplaga*.
 3. UnF discal spots small as usual: upH distal border narrow with distal spots clearly visible. *nearcha*.
 4. F cell as long as, or longer than, half length of wing.
 5(14). ♂ F apex very acute and distal border broad, particularly at apex. ♀ with broad costal and distal borders, the latter often continued along basal margin.

puspa group.

6(13). UnF discal spots not very broad and not more heavily marked than usual. ♂ without androconia.
 7(10). ♂ deep purple above with broad black border, which is regularly defined, on both wings, this border increasing considerably at F apex.
 8 (9). Wing expanse under 21 mm. ♂ F costa not broadly black. ♀ F above black with pale blue oval patch whose apical end is rather pointed: veins in discal patch lightly dark dusted *moultoni*.
 9. Wing expanse above 21 mm. ♂ F with broad black costal border. ♀ above black with a narrow, obscure, greenish-blue discal patch in which veins are heavily dark dusted *lenya*.
 10. ♂ lustrous blue above. ♀ with prominent pale discal patches and broad costal and distal borders.
 11(12). UnH no minute black dot at extreme base of space 7. Un chalky-white. ♀ pale shining blue, with small white discal patches and comparatively narrow F costal and distal borders *cossaea*.
 12. UnH with minute black dot at extreme base space 7. ♂ lustrous to dull blue. ♀ white, with both wings basally washed with blue and usual broad costal and distal borders *puspa*.
 13. UnF discal spots very broad and heavily marked. ♂ above lustrous blue with white discal patches; androconia present. ♀ with broad white discal patches, usual broad costal and distal borders, and only extreme wing bases blue dusted *carna*.
 14. ♂ F apex rounded and apex not broadly black bordered: androconia always present. ♀ with broad costal and distal borders, the latter not continued far along basal margin.
 15(31). UnF discal streaks forming a regular curve, not *en échelon*.
 16(22). Wing expanse greater than 31 mm.

corythus group.

17(18). UnH marginal spots not inwardly defined by a series of submarginal lunules. ♂ up with large white discal patches on both wings. *corythus*.
 18(21). UnH marginal spots inwardly defined by submarginal lunules in anal half of wing.
 19(20). ♂ upF black distal border a thread and clearly defined *coalita*.
 20. ♂ upF black distal border broader and inwardly diffuse *idamis*.
 21. UnH marginal spots inwardly defined throughout length of distal margin by a series of submarginal lunules. ♂ UpF black distal border broader than *coalita* and clearly defined. ♀ resembles a species of *Deilemara* (ARCTIIDAE) above *catreus*.
 22. Wing expanse less than 31 mm.

akasa group.

23(24). UpF white in both sexes, except for black borders *akasa*.
 24. UpF blue (lavender-blue in ♀ *camenae*), with or without white discal patch.
 25(28). ♂ upF distal border greater than 2 mm. at apex.
 26(27). ♂ upH mainly white, with veins dark dusted and distal spots *aristinus*.
 27. ♂ upH white, except for a small blue basal area *albocaeruleus*.
 28. ♂ upF distal border less than 2 mm. at apex.
 29(30). UnF discal spots form an evenly curved arc. ♂ upF bright lustrous blue, black distal border increasing noticeably from tornus to apex.
 ♀ bright blue, with broad costal and distal borders upF *ceyx*.
 30. UnF discal spots more or less parallel to distal margin and costal spot shifted inwards and out of line with the rest. ♂ upF dull blue, distal border more uniform, increasing only slightly at apex. ♀ white, washed with lavender-blue, with broad costal and distal borders upF *camenae*.
 31. UnF discal streaks *en échelon*.
 32. Wing expanse less than 24 mm.

musina group.

33. ♂ up blue with narrow black bordering; wedge-shaped androconia.
 ♀ dull blue with broad black bordering *musina*.
 34. Wing expanse greater than 24 mm.

singalensis group.

35(38). Un white, markings rather faint. ♂ upF black distal border a thread.
 36(37). ♂ up violet-blue, no pale blue discal patches. ♀ blue with broad costal and distal borders upF *singalensis*.
 37. ♂ up pale blue, with pale discal patches which may be obsolete. ♀ white, washed with lavender-blue and dark dusted, and with broad costal and distal borders upF *dilecta*.
 38. Un grey, markings heavier and often edged with white. ♂ with broader black distal border upF.
 39(40). ♂ upF distal border inwardly diffuse, less than 2 mm. wide and increasing towards apex. ♀ deep blue comparatively narrow costal and distal borders upF *lavendaris*.
 40(41). ♂ upF distal border narrower, inwardly rather diffuse and of uniform width throughout: in the Malayan and Sumatran forms the F and H veins are darkened before entering the dark borders. ♀ white, faintly washed with lavender-blue, and with broad costal and distal borders upF *placidula*.
 41. ♂ upF distal border at least 2 mm. broad, increasing at apex and tornus: above deep purple and usually only extreme base H is blue. ♀ rather pale blue with broad costal and distal borders upF: veins in discal patch F not darkened as in *moultioni*. ♀ un whiter than in ♂ *pellecebra*.

1. *Celastrina nearcha* Fruh.

Lycaenopsis quadriplaga nearcha Fruhstorfer, 1917, *Arch. Naturgesch.*, 82 (A) (1): 38 (♂, N.E. Sumatra).

L. quadriplaga nearcha Fruhstorfer, 1922, *Grossschmett. Erde*, 9: 876, pl. 152 d (8) ♂.

On the basis of differences in the male genitalia, Toxopeus considered that *nearcha* is not conspecific with the Javanese *quadriplaga* Snell. The Javanese species (of which *dohertyi* Tytler is the Burmese race) has broader black bordering and is a much darker butterfly than *nearcha*. The only Malayan male of

nearcha in my collection differs from Sumatran specimens in its smaller size, in the fore-wing distal border being more incurved along the basal margin, in the more restricted basal blue dusting and in the more distinct underside markings : it is doubtful, however, if the differences are sufficient to merit subspecific distinction. The Bornean species *boulti* Chapm. (1912, *Ent. mon. Mag.*, (2) 23 : 103*) is closely related, as the figures of the male genitalia show. The male genitalia of Sumatran *nearcha* and Javanese *quadriglapa* have been figured by Fruhstorfer (1917, *loc. cit.*, pl. i, fig. 11) and Toxopeus (1927, *loc. cit.* : 278, fig. 15) respectively.

2. *Celastrina moultoni* Chapm.

Lycaenopsis moultoni Chapman, 1911, *Trans. ent. Soc. Lond.*, 1911 : 184, pl. xxviii, fig. 5 ♂, 6 ♂ und. (♂ Sarawak, British Museum).

Lycaenopsis moultoni Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 867, pl. 153 f (7) ♂, (8) ♀.

Of this species, hitherto known only from Borneo, seven males and one female were taken in Selangor (Bukit Kutu, 3485 feet, *A. S. Corbet*) in March 1931. The male can be recognised from the figure in Seitz, but the female is

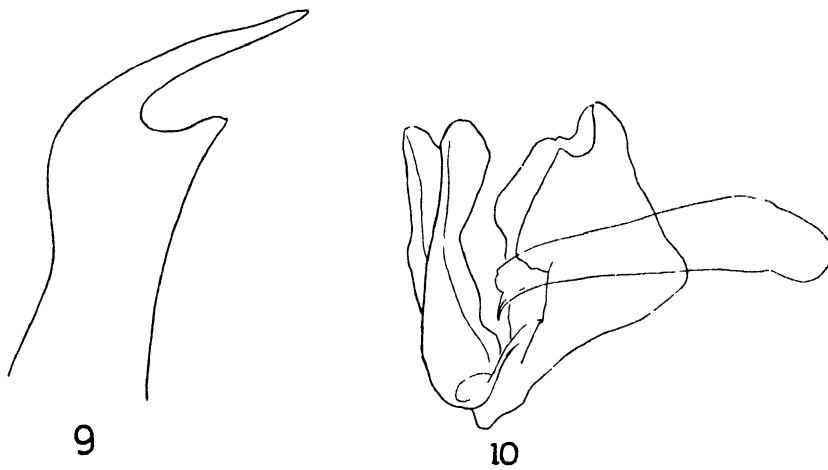


FIG. 9.—Tip of male clasper
C. puspa lambi.

FIG. 10.—Male genitalia of *C. lenya*.

rather close to *pellecebra* from which it differs, not only in the smaller size, but in that the veins crossing the fore-wing pale discal patch are lightly dark dusted and this pale patch is distally rather pointed.

3. *Celastrina lenya* Evans.

Lycaenopsis chelaka lenya Evans, 1932, *Ident. Indian Butt.* : 222 (♀ Lenya Valley, South Burma, British Museum).

C. lenya is not conspecific with *chelaka* Moult., which pertains to the genus *Lycaenopsis* Feld. & Feld. and is known only from Borneo.

The male of *lenya* resembles the male of *moultoni* above and below but is larger in size (27 mm. against 20 mm.) and the fore-wing apex is less acute : the female is black above and the fore-wing bears a narrow, obscure, greenish-blue discal patch, on which the veins are heavily black dusted.

* This reference is incorrectly given in Seitz, *Grossschmett. Erde*, 9.

A female from peninsular Siam (Khao Ram, 3000 feet, March 1922), in the British Museum from the collection of Brigadier W. H. Evans, has the fore-wing discal streak longer and much paler blue than in the type. In my collection are two males from Bukit Kutu (3485 feet) taken in March 1931, and a female from Tanah Rata (4000 feet) on 1st February 1930: the last-named does not differ from the type.

The genitalia of the male *lenya* resembles that of *moultoni* and shows a close relationship with that of *Megisba malaya* Hsf.

4. *Celastrina puspa lambi* Dist.

Polyommatus (Cyaniris) lambi Distant, 1882, *Ann. Mag. nat. Hist.*, (5) 10 : 245 (Malay Peninsula). *Cyaniris lambi* Distant, 1884, *Rhop. Malay.* : 211, pl. xxi, fig. 22 ♂.

Lycaenopsis puspa lambi Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 869.

L. puspa lambi Corbet & Pendlebury, 1934, *Butt. Malay. Pen.* : 190, pl. xiii, fig. 173 ♂ und.

This butterfly is generally distributed on the plains in Malaya but occasional examples are taken at altitudes up to 4800 feet. It is very variable and large males with bright lustrous blue upperside, broad black bordering and the hind-wing produced contrast with examples of smaller size, duller colouring and obscure white discal patches on both wings and more rounded hind-wing tornus. The male claspers of extreme forms are identical and intergrades occur: specimens from high altitudes tend to be of the smaller and duller type. A series of males in the Selangor Museum from Pulau Tioman (June-July 1916, *H. C. Robinson* and *C. B. Kloss*) appear to be referable to the subspecies *volumnia* Fruh. (1922, Seitz, *Grossschmett. Erde*, 9 : 870) from the Natuna Islands; they are smaller than *lambi* from the mainland, of a more purple-blue colour and with narrow black bordering to both wings.

The Malaysian subspecies of *puspa* are *lambi* Dist. (Malaya), *mygdonia* Fruh. (Sumatra), *puspinus* Kheil (Nias), *puspa* Hsf. (West Java), *sania* Fruh. (East Java), *tymbria* Fruh. (Borneo), *volumnia* Fruh. (Natuna Islands and Pulau Tioman) and *vandeldeni* Tox. (Pulau Weh).

5. *Celastrina cossaea distanti* Fruh.

Cyaniris cossaea distanti Fruhstorfer, 1910, *Stettin. ent. Ztg.*, 71 : 288 (Malay Peninsula).

Lycaenopsis cossaea distanti Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 867.

Cyaniris sp. ?, Distant, 1886, *Rhop. Malay.* : 453, pl. xlii, fig. 10 ♂ nec ♀.

The Malayan race differs but little from the Sumatran *cossaea cossaea* figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 d (3) ♀ and (2) ♀ und. In the Peninsula it is a rare species occurring in open spaces in the forest on the plains and at altitudes up to 3500 feet (Bukit Kutu in my collection).

The Malaysian races are *distanti* Fruh. (Malaya), *cossaea* Nic. (Sumatra), *hegesias* Fruh. (Nias), *sabatina* Fruh. (Java) and *sonchus* Drc. (Borneo). The Bornean *C. plauta* Drc. appears to be a distinct species.

6. *Celastrina carna splendens* Btlr.

Cyaniris splendens Butler, 1900, *Ann. Mag. nat. Hist.*, (7) 5 : 444 (♂ Larut Hills, Perak, British Museum).

Lycaenopsis marginata carna Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 874 (partim).

Lycaenopsis puspa splendens Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 869.

Both Fruhstorfer and Toxopeus incorrectly identified *splendens* as a form of *C. puspa lambi* Dist. The male *splendens* is darker blue and the white areas rather more restricted than in the figured *carna* (Seitz, *Grossschmett. Erde*, 9

pl. 152 d (7) ♂) from Sumatra. The underside markings, particularly the fore-wing discal band, are darker and more prominent in the Malayan race.

The female has not yet been described.

♀ *Upperside.* Closely resembles the figure of " *contilia* " in Seitz, *Grossschmett. Erde* 9 pl. 152 c (6),* the blue dusting being confined to the wing bases. Differs from the female of the Javanese *carna carnita* Fruh. in the heavier fore-wing basal border and the dark black dusting in the anal half of the hind-wing.

Underside. Ground-colour much whiter than in the male. Markings arranged as in that sex, but the spots comprising the fore-wing discal band are smaller and more separated.

Wing expanse 29.5 mm.

MALAY PENINSULA, Perak, Maxwell's Hill, 3800 feet, 20th September, 1929,
A. S. Corbet. (*Neallootype*.)

7. *Celastrina corythus toxopeusi* subsp. n.

♂. *Upperside.* Ground-colour more purple-blue, white areas more restricted, broader black bordering to both wings and hind-wing veins more heavily dusted with purple-blue than in nymotypical *corythus* Nic. from north-east Sumatra.

Underside. Colour and markings as in *corythus*, but, in the specimen under examination, the discal streaks on the fore-wing are more prominent.

Wing expanse 33.5 mm.

MALAY PENINSULA, Pahang, Cameron Highlands, Tanah Rata, 4800 feet, 20th May, 1931, *H. M. Pendlebury.* (*Holotype*.)

Hitherto *C. corythus* has been known only from the mountains of Sumatra. It is figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 d (1) ♂. The new subspecies is named after Dr. L. J. Toxopeus.

8. *Celastrina coalita margarelon* Fruh.

Lycaenopeis coalita margarelon Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 866 (North-east Sumatra).

Typical *coalita* Nic. occurs in Java, and the species can now be added to the Malayan list. A male from Pahang, July 1925, in the British Museum (from the collection of Brigadier W. H. Evans) agrees with Sumatran *margarelon* in all respects: in a second male (Pahang, Gunong Batu Brinchang, 5000-5500 feet, 27th March, 1932, *A. S. Corbet*) the underside markings are very prominent and the streaks comprising the fore-wing discal band are much broader and heavier than in the Sumatran form.

The Malaysian races of *coalita* are *margarelon* Fruh. (Malay Peninsula and Sumatra), *polemonia* Tox. (West Java) and *coalita* Nic. (East Java and Bali).

Two rather similar species, *idamis* Fruh, and *catreus* Nic., have not yet been found in the Malay Peninsula. The differences between these three closely allied species are shown in the key. *C. idamis* is confined to Sumatra but *C. catreus* has a wider distribution with the subspecies *gaius* Fruh. (Sumatra), *catreus* Nic. (West Java) and *hermeias* Fruh. (East Java).

* From the original description and the figures in Seitz, 9, it is evident that *contilia* Fruh., from the Lesser Sunda Islands, is a *carna* subspecies.

9. *Celastrina akasa catullus* Fruh.

Cyaniris akasa catullus Fruhstorfer, 1910, *Stettin. ent. Ztg.*, 71 : 283 (Sumatra).

Lycaenopsis akasa catullus Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 862, pl. 152 e (8) ♂ und., (7) ♀.

The species is often locally common at high altitudes in Malaya and occasional examples are found on the forested foothills. Sumatran specimens are rather larger and the underside markings more distinct than in examples from the Malay Peninsula.

The nymotypical form *akasa akasa* Hsf. occurs in Java.

10. *Celastrina aristinus klossi* subsp. n.

♂. *Upperside*. Differs from typical *aristinus* Fruh. from Java in the much more purple colour and in the much broader black fore-wing border which increases in width from 2 mm. at the tornus to 5 mm. at the apex; on the hind-wing the veins are more prominently dark dusted.

Underside. Colour and markings similar to those of the male *aristinus* figured in de Nicéville, 1892, *J. Bombay nat. Hist. Soc.*, 7, pl. H, fig. 7, ♂ nec ♀, as "ceyx."

Wing expanse 31 mm.

MALAY PENINSULA, Pahang, Pulau Tioman, June-July 1916, *H. C. Robinson & C. B. Kloss*. (*Holotype*.) Erroneously recorded as "*Lycaenopsis corythus*" by Evans, 1933, *J.F.M.S. Mus.*, 17 : 407.

In general appearance *aristinus* resembles the figured Celebean *aristius* Fruh. in Seitz, *Grossschmett. Erde*, 9 pl. 152 e (7) ♂, but the fore-wing has a broader distal band and a white discal patch and the hind-wing veins are dark dusted. Although *aristinus* and *aristius* are similar in appearance and have rather similar male genitalia, Toxopeus regarded them, at least provisionally, as distinct species, a view with which I am in agreement. Apart from the Tioman specimen, *aristinus* is known only from Java, where it is rare. The new subspecies is named after Mr. C. B. Kloss, formerly Director of Museums, S.S. & F.M.S.

11. *Celastrina albocaeruleus scharffi* subsp. n.

♂. *Upperside*. On the fore-wing the white discal area is more restricted and the black distal border about twice as broad as in the Sumatran race *ovianus* Fruh.; the general appearance of the upperside is nearer that of *albocaeruleus* Mr. from North India figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 f (2) ♂.

Underside. Markings arranged as in *ovianus* but more distinct.

Wing expanse 26 mm.

MALAY PENINSULA, Pahang, Fraser's Hill, 4250 feet, 3rd June, 1932, *Dr. J. W. Scharff*. (*Holotype*.)

In another Malayan male (Pahang, Cameron Highlands, Tanah Rata, 4000 feet, 31st January, 1930, *A. S. Corbet*) the fore-wing black distal border is distinctly broader and the wings are longer (wing expanse 27.5 mm.)

A male paratype of *C. ceyx nix* Tox. (East Java, Gunong Lawu, 1400-1800 m., 27th June, 1926, *C. J. F. Denker*) in the British Museum is a male *albocaeruleus*, differing from the Sumatran *ovianus* only in the slightly larger white discal area and rather broader black bordering at the apex on the fore-wing.

At first sight it might be supposed that *dilectissima* Drc. is the Bornean representative of *albocaeruleus*; the genitalia differ so distinctly, however, that it is evident that no very close relationship exists between the two species.

12. *Celastrina ceyx tanarata* subsp. n.

♂. *Upperside.* Differs from *C. ceyx elothes* Fruh. from Sumatra in the darker and deeper blue colour of both wings and in the very restricted white apical area of the hind-wing.

Underside. Colour and markings as in *elothes*.

Wing expanse 26.5 mm.

MALAY PENINSULA, Selangor, Bukit Kutu, 3485 feet, 22nd March, 1931, *A. S. Corbet.* (*Holotype.*) Other males from Perak, Larut Hills; Selangor, Bukit Kutu (3485 feet); Pahang, Fraser's Hill (4250 feet) and Cameron Highlands (4000 feet).

♀. *Upperside.* Both wings dull purple-blue, appearing pale lustrous blue by reflected light. *Fore-wing*: broad black costal and distal borders, the former increasing in width towards the apex and inwardly diffuse. Distal border 1.5 mm. at narrowest part, increasing in width towards apex and tornus; inwardly very diffuse and veins darkened a short distance before entering the distal border. The wing base lightly black dusted, a cell-end streak faintly visible, and an almost obsolete white discal spot. Cilia black, becoming white at tornus. *Hind-wing*: a black costal border extending to vein 6; a black, inwardly diffuse, distal border (about 1 mm. broad) on which interneural dark spots are faintly visible. Wing base lightly black dusted and indications of a white discal area. A dark costal spot in space 7 showing through from beneath. Cilia white, becoming black at tornus.

Underside. Ground-colour whiter than in male; markings similar but rather smaller. Wing expanse 24 mm.

MALAY PENINSULA, Selangor, Bukit Kutu, 3485 feet, 14th March, 1931, *A. S. Corbet.* (*Allotype.*) Other females examined from Pahang, Cameron Highlands and Fraser's Hill.

The female *tanarata* differs from the female *ceyx ceyx* from West Java in the much darker colouring and broader bordering above (particularly in the black dusting on the hind-wing): the males of *ceyx* become progressively whiter on proceeding from Malaya, through Sumatra, to West and East Java. The upperside and underside of the Bornean *ceyx selma* Drc. is figured in Seitz, *Grossschmett. Erde*, 9 pl. 154 c (3) ♂. In addition to the Malaysian subspecies mentioned above, *ceyx nix* Toxopeus occurs in East Java.

***Celastrina ceyx cerima* subsp. n.**

A male from Dawnas, Burma (November 1921), in the British Museum from the collection of Brigadier W. H. Evans, differs from the Malayan race in the broader fore-wing distal border and in the more prominent white subapical patch on the hind-wing (wing expanse 30 mm.). I name it *cerima* subsp. n.

13. *Celastrina camenae pendleburyi* subsp. n.

Cyaniris camenae de Nicéville, 1895, *J. Bombay nat. Hist. Soc.*, 9 : 278 (partim).

Lycaenopsis camenae camenae Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 863, pl. 152 g (3)

♂ as "camenae."

Lycaenopsis carna Corbet & Pendlebury, 1934, *Butt. Malay. Pen.*, pl. xiii, fig. 172 ♂ und.

♂. Differs from typical *camenae* from North-east Sumatra only in the more restricted and less prominent white area in the costal area of the hind-wing above.

Wing expanse 28 mm.

MALAY PENINSULA, Perak, Maxwell's Hill, 4500 feet, 16th September, 1929,
A. S. Corbet. (*Holotype.*)

♀. *Upperside.* In general appearance resembles the female *camenae* from Sumatra figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 g (4), but the ground-colour is a rich lavender-blue, the fore-wing black bordering is broader and slightly curved inwards at the tornus, and the hind-wing is dark dusted rather broadly along the costal and distal margins. Both wings have prominent pale discal patches and cell-end spots are visible as in *camenae camenae*.

Underside. Colour and markings exactly as in male.

Wing expanse 26 mm.

MALAY PENINSULA, Perak, Maxwell's Hill, 3800 feet, 16th September, 1929, *A. S. Corbet.* (*Allotype.*) Other females examined from Perak, Larut Hills; Pahang, Fraser's Hill (4250 feet) and Gunong Tahan (5500 feet).

I wish to associate the name of this new *camenae* race with that of Mr. H. M. Pendlebury.

Fruhstorfer considered the Malay Peninsula as the type locality of *camenae* and described *elothales* as the Sumatran race; the male holotype of this latter form is in the British Museum and is conspecific with *ceyx* Nic. Toxopeus regarded Sumatra as the type locality of *camenae* and stated that *cossa* Chapm. (1909, *Proc. zool. Soc. Lond.* 1909 : 453) was a name available for the Malayan race, if differing from Sumatran *camenae*. The male holotype of *cossa* in the British Museum originated from Sumatra and not the Malay Peninsula, as Toxopeus supposed. I have ascertained that the male type of *camenae* in the Indian Museum, Calcutta, is labelled "Cyaniris camenae de Nicéville, ♂ Type, Sumatra, No. 15639 (Coll. de Nicév.)," so that *cossa* Chapm. sinks as a synonym of *camenae*.

Toxopeus stated that no females of *camenae* were known, but there can be no reasonable doubt that the "*camenae*" figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 g (4), and of which the original is stated by Toxopeus to be in the Munich Museum, is, in fact, a female of the Sumatran *camenae camenae*. Toxopeus regarded this female specimen, and probably correctly, as the female type of *elothales* Fruh., but the holotype of *elothales* is a male and not conspecific with the female figured on plate 152 as "*camenae*."

C. camenae and *C. ceyx* are very similar in the male (the females differ considerably) and have been confused repeatedly in the literature. Above, the male *camenae* is a rather dull blue, the narrow black distal border almost uniformly broad on both wings and the discal spots show through from beneath. The upperside of the Malayan *ceyx* is bright lustrous blue, the fore-wing black border considerably broader than that of the hind-wing and increasing markedly towards the apex; the underside markings do not show through. In both species the markings of the underside are very similar and a little variable: while in *ceyx* the fore-wing discal series of spots are apically bent inwards and form a regular curve, in *camenae* these spots remain more or less parallel to the wing margin and the costal spot is always out of line with the others. In *camenae* there is a tendency for the discal spots to be placed *en échelon* while they are always straight in *ceyx*.

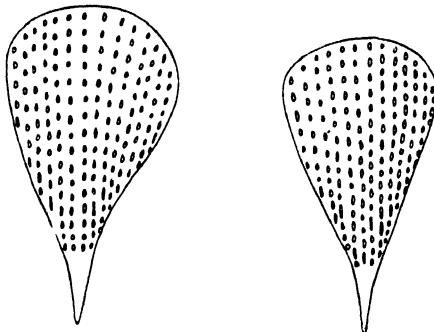
In Borneo occurs a dark race, *C. camenae strophis* Drc., of which the female appears to be unknown. The figure in Seitz, *Grossschmett. Erde*, 9 pl. 154 c (2) ♂, is reasonably accurate.

14. *Celastrina musina candaules* Nic.

Cyaniris candaules de Nicéville, 1895, *J. Bombay nat. Hist. Soc.*, 9 : 276 (♂ Sumatra, Indian Museum, Calcutta).

Lycaenopsis musina candaules Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 876, pl. 152 h (2) ♀ as "musina."

The male *candaules* is much like the Javanese *musina musina* figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 h (1). The long, wedge-shaped androconia on the wings of the males admit of the ready separation of *musina* from all other Malaysian *Celastrina*. Males of *musina musinoides* Swinh. from Assam and



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FIG. 11.—Androconial scales of *C. musina candaules*.

Burma differ from *musina candaules* in the appreciably broader black bordering on both wings : *parishii* Rhé Phil. (described from Assam) falls as a synonym of *musinoides* Swinh. I have seen no females of *candaules* from Sumatra, but should these differ from Malayan examples, a new name must be found for the Malayan race.

In the Peninsula the species is confined to the forested hills.

The other Malaysian races are *musina* Snell. (Java) and *lugra* Drc. (Borneo).

15. *Celastrina singalensis xanthippe* subsp. n.

This species has not been hitherto recorded definitely from the Malay Peninsula. In Malaysia, the males of *singalensis* and *dilecta* are deceptively alike but they can always be separated from the appearance of the upperside : in *singalensis* the wings are uniformly coloured a rather rich violet-blue and there is no suggestion of a white discal area on either wing ; in *dilecta* the wings are more purple and rather paler and almost always there are at least indications of white discal patches on both wings. A male *singalensis* could hardly be passed over in a series of males of *dilecta*. Often the underside of *singalensis* is distinctive in the mat surface with reddish-brown markings, but these characters grade into the usual *dilecta* markings : as far as the Ceylon and Malaysian forms of *singalensis* are concerned, there is a distinct tendency for the fore-wing submarginal strigae to consist of a series of straight streaks, and not to be lunulate as in *dilecta*, and for the more distal costal spot on the hind-wing to be streak-like instead of circular. The females of *singalensis* and *dilecta* are quite distinct.

♂ Upperside. Closely resembles the male holotype of *C. singalensis catus* Fruh. from Sumatra, but the hind-wing border is more prominent.

Underside. Colour and markings similar to *catius* but the markings are broader and rather more diffuse. Both upperside and underside hardly differ from typical *singalensis* Feld. from Ceylon.

Wing expanse 36 mm.

MALAY PENINSULA, Pahang, Cameron Highlands, Rhododendron Hill, 5200 feet, 22nd June, 1923, *H. M. Pendlebury*. (Holotype.)

A smaller male in my collection (Selangor-Pahang, Semangko Pass, 2800 feet, 19th February, 1929, *A. S. Corbet*) corresponds closely to the male holotype of *singalensis astarga* Fruh. from Java and the underside has a glistening surface and resembles the " *singalensis* " figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 f (6) ♂ und. The genitalia of the two males are identical and the clasper of the Semangko Pass specimen is figured.

♀. *Upperside.* Deep purple-blue with the fore-wing black costal and distal borders broader than in typical *singalensis* from Ceylon; the hind-wing pale discal patch almost obsolete. The fore-wing black distal border is not continued for a short distance along the basal margin as in the female *astarga* (Toxopeus, 1928, *loc. cit.*, pl. v, fig. 11).

Underside. Colour and markings as in typical *singalensis*.

Wing expanse 31 mm.

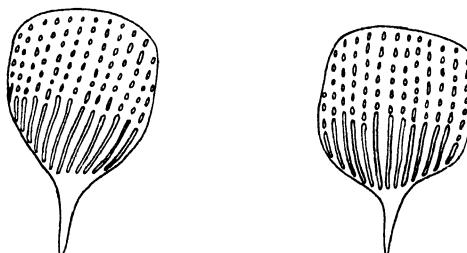
MALAY PENINSULA, Pahang, Cameron Highlands, Rhododendron Hill, 5200 feet, 13th October, 1923, *H. M. Pendlebury*. (Allotype.)

16. *Celastrina dilecta briga* Fruh.

Lycaenopsis cardia briga Fruhstorfer, 1917, *Arch. Naturgesch.*, 82 (A) (1) : 15 (♂ Perak).
Lycaenopsis cardia briga Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 865.

The type of *briga* is Chapman's aedeotype of Malayan *dilecta* Mre.

The males exhibit some variability in the extent and intensity of the white discal patches on the upperside; these areas may be almost obsolete, or large and prominent, as in an example in my collection from Gunong Batu Brinchang



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FIG. 12.—Androconial scales of *C. dilecta briga*.

(5000–5500 feet, 27th March, 1932, *A. S. Corbet*). The underside markings are arranged as in " *thoria* " figured in Seitz, *Grossschmett. Erde*, 9 pl. 152 g (1) ♂ und.

The male of the Sumatran *C. dilecta neodilecta* Fruh. hardly differs from *briga* except that the underside markings may be rather more prominent and edged with white, as in *C. placidula intensa* Tox.

The female of *briga* has not been described.

♀. *Upperside*. Resembles the figure of "thoria" ♀ in Seitz, *Grossschmett. Erde*, 9 pl. 152 f (8) in general appearance, but the ground-colour is a more lavender-blue and the fore-wing distal black border is broader. Differs from the Javanese *C. dilecta paradilecta* Fruh. in the heavier black dusting, particularly on the hind-wing.

Underside. Whiter than in the male; markings identical.

Wing expanse 24 mm.

MALAY PENINSULA, Selangor-Pahang border, Ginting Simpah, 2080 feet, 6th April, 1930, A. S. Corbet. (*Neoallotype*.)

Although *C. dilecta briga* is a montane insect, occasional specimens are taken on the forested plains.

The Malaysian forms of *C. dilecta* are *briga* Fruh. (Malaya), *neodilecta* Fruh. (Sumatra), *paradilecta* Fruh. with f. *phoenix* Tox. and ab. *bruggemanni* Tox. (West Java), *subcoalita* Roths. with ab. *dammermanni* Tox. (East Java), and *paracatius* Fruh. (Borneo). Typical *dilecta* Mre. from Nepal.

17. *Celastrina lavendularis isabella* subsp. n.

Cyaniris placida Distant, 1886, *Rhop. Malay.* : 453, pl. xliv, fig. 7 ♂.

Lycaenopsis limbata placida Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 872 (partim).

♂. *Upperside*. Deep blue with rather broad, inwardly diffuse, black borders to both wings, these borders increasing in width towards the apexes, as in typical *placida* Nic. from Sikkim. Differs from *placidina* Fruh. from North-east Sumatra (*not* figured as "placida" in Seitz, *Grossschmett. Erde*, 9 pl. 152 f (5) ♂ und., which represents *C. placidula intensa* Tox.) in the rather darker colouring and broader bordering to both wings.

Underside. Markings identical with typical *placida* from Sikkim and *placidina* from Sumatra, but the ground-colour appreciably greyer and darker than in either of these subspecies.

Wing expanse 28.5 mm.

MALAY PENINSULA, Perak, Maxwell's Hill, 3800 feet, 9th September, 1929, A. S. Corbet. (*Holotype*.)

Some males of *isabella* are deceptively like that sex of *C. puspalambi*, but the presence of androconia and the absence of a minute black spot at the extreme base of space 7 on the hind-wing beneath in the first-named affords a ready means of separating the two.

♀. *Upperside*. Ground-colour a deep lavender-blue, increasing in intensity towards the wing bases, instead of white with blue-dusted basal thirds as in *placida* from Sikkim. Fore-wing with broad black costal and distal borders, the latter being incurved at the tornus; a dark streak at the cell-end, and the basal margin narrowly black dusted. Hind-wing with a black costal border extending to vein 6 and a distal border comprising a black marginal thread, a series of black interneural spots (hardly increasing in size from tornus to apex) inwardly edged with white, and an inner black sinuate line. On both wings the veins are black dusted in the discal area. Cilia on both wings dirty white.

Underside. Ground-colour whiter than in the male; markings identical.

Wing expanse 25.5 mm.

MALAY PENINSULA, Pahang, Fraser's Hill, 4250 feet, 1st June, 1932, A. S. Corbet. (*Allotype*.)

The male of *floresiana* Courv.* from Java differs from the subspecies from

* *floresiana* Courv. = *limbatus pellax* Fruh. Fruhstorfer first described *Cyaniris placida pellax* (1910, *Stettin. ent. Ztg.*, 71 : 292) from a male *Rhinelephas* which he mistook for a female. Later, he associated a male *lavendularis* from Lombok with this supposed Javanese female under the name of *Lycaenopsis limbatus pellax* (1917, *Arch. Naturgesch.*, 82 (A) (1) : 31).

Malaya and Sumatra by the brighter colouring, narrower black bordering and much diminished black spotting on the hind-wing distal margin. The male of *hegesander* Fruh. from Tonkin resembles *isabella* but the black bordering is hardly more than half as wide.

18. *Celastrina placidula irenae* subsp. n. -

Lycaenopsis limbata placidina Fruhstorfer, 1922, Seitz, *Grossschmett. Erde*, 9 : 873 (partim). The figure on pl. 152 f (5) ♂ und. as "placida" is a good representation of the Malayan or Sumatran male.

Celastrina placidula intensa Toxopeus, 1928, *Tijd. Ent.*, 71 : 241 (partim).

♂. Differs from *C. placidula intensa* from Sumatra only in that the underside markings are slightly heavier and the costal spot in space 7 on the hind-wing is somewhat larger.

Wing expanse 29 mm.

MALAY PENINSULA, Pahang, Fraser's Hill, 4250 feet, 3rd June, 1932, Dr. J. W. Scharff. (*Holotype*.)

Malayan and Sumatran *placidula* males differ from other *Celastrina* species in the darkened veins in the distal part of the hind-wing.

♀. *Upperside*. Ground-colour white with the basal half of the fore-wing and the basal two-thirds of the hind-wing pale lavender-blue. The fore-wing costal and distal black borders are broader than in ♀ *intensa* from Sumatra (Toxopeus, 1935, *Ent. Med. Ned.-Indië*, 1 : 71, pl. vi, fig. 1) and the basal margin is black dusted. Hind-wing with distal bordering broader than in *intensa* and anal and basal parts of the wing lightly black dusted. On both wings the veins are lightly dark dusted.

Underside. Ground-colour much whiter than in the male. Markings identical but not fringed with white as in the male.

Wing expanse 27 mm.

MALAY PENINSULA, Selangor, Bukit Kutu, 3485 feet, 9th March, 1931. A. S. Corbet. (*Allotype*.)

Both sexes of *C. placidula irenae* differ from *C. placidula snelleni* Tox. from Java in the darker colouring and broader bordering of the upperside. Typical *placidula* Drc. (1875, *Proc. zool. Soc. Lond.*, 1875 : 572) * flies in Borneo : in the figure in Seitz, *Grossschmett. Erde*, 9 pl. 154 b (6) ♂, the upperside is correct but the underside ground-colour is too white and the markings too regular.

The new subspecies is named after my wife.

19. *Celastrina pellecebra cyma* Tox.

Celastrina cyma Toxopeus, 1927, *Tijd. Ent.*, 70 : 272 (♂ Malay Peninsula).

Cyaniris jynneana var. Distant, 1886, *Rhop. Malay.* : 452, pl. xliv, fig. 6 ♂.

Lycaenopsis melaena melaena Fruhstorfer (*nec* Doherty), 1922, Seitz, *Grossschmett. Erde*, 9 : 862, pl. 152 g (7) ♂.

Fruhstorfer described *Cyaniris pellecebra* (1910, *Stettin. ent. Ztg.*, 71 : 296) from Sumatra, and the female holotype and male allotype are in the British Museum. The male closely resembles and is clearly conspecific with *cyma* Tox., from Malaya. The female is certainly not a *puspa* form, as Toxopeus supposed, and there is no reason for doubting that the male and female are correctly paired.

Although Sumatran *pellecebra* and Malayan *cyma* hardly differ, it seems advisable to allow the latter name to stand. In the Joicey collection, in the

* This reference is incorrectly given in Seitz, *Grossschmett. Erde*, 9.

British Museum, is a male from Mount Matang (3000 feet), Sarawak, which is perhaps nearer to *cyma* than to *pellecebra*.

In the male of the collective species, the hind-wing border can be comparatively narrow, as in the ♂ " *melaena* " figured in Seitz, or so broad as to cover almost the whole of the wing. The genitalia of the two forms are identical.

The male of *pellecebra* differs from *moultoni* and *lenya*, not only in the much more rounded fore-wing apex, but in that the fore-wing black distal border is incurved along the basal margin.

The female of *C. pellecebra cyma* has not yet been described.

♀. *Upperside*. Differs from ♀ *pellecebra* (Seitz, *Grossschmett. Erde*, 9 pl. 152 g (8)) in the somewhat broader fore-wing costal border and in the more extended blue dusting on the pale discal patch.

Underside. Ground-colour much whiter than in the male and with very little reddish dusting. Markings narrower and finer than in the male and, on the hind-wing, the inner black costal spot in space 7 and the inner black spot along the basal margin are absent.

Wing expanse 23.5 mm.

MALAY PENINSULA, Selangor-Pahang, Ginting Simpah, 2080 feet, 3rd June, 1929, A. S. Corbet. (*Neoallotype*.)

Two Selangor Museum females, from Bukit Kutu (3300-3500 feet) and Fraser's Hill (4000 feet) respectively, differ only in the longer fore-wings (wing expanse 29-30 mm.).

In addition to the forms dealt with above, the following species of *Celastrina* occur in Borneo : *lingga* Moult., *boulti* Chapm. (1912, *Ent. mon. Mag.*, (2) 23 : 103 *), *plauta* Drc., *shelfordi* Nic. (= *armeta* Fruh.), *ripte* Drc., *nigerrimus* Moult. and *dilectissima* Drc. As yet, none of these species has been found outside Borneo.

During the course of the work the following British Museum types have been examined : *akasa* Hsf., *albocaeruleus* Mrc., *astarga* Fruh., *boulti* Chapm., *catius* Fruh., *cossa* Chapm., *dilecta* Mrc., *eloiales* Fruh., *hegesander* Fruh., *idamis* Fruh., *lenya* Evans, *limbata* Mrc., *lingga* Moult., *marginata* Mrc., *moultoni* Chapm., *musinoides* Swinh., *neodilecta* Fruh., *nigerrimus* Moult., *ovianus* Moult., *paracatius* Fruh., *parishi* Rhé Phil., *limbatus pellax* Fruh., *pellecebra* Fruh., *placidina* Fruh., and *splendens* Btlr., and *cardia* Feld. has been examined at Tring. Two paratypes in the British Museum are *nix* Tox. and *snelleni* Tox. The types of *briga* Fruh. and *cyma* Tox. should be in the British Museum but cannot be found. Of the new subspecies described in the present paper, the types of *klossi*, *toxopeusi* and *xanthippe* are in the Selangor Museum, that of *cerima* is in the British Museum, and the remainder are in my own collection but all holotypes will be assigned to the National collection.

I am indebted to the authorities of the British Museum (Natural History) for granting facilities for the study of their collections, to Lord Rothschild for permission to examine certain types at Tring, and to Mr. H. M. Pendlebury for the loan of specimens from the rich collections in the Selangor Museum. Again I have pleasure in acknowledging indebtedness to Brigadier W. H. Evans, C.S.I., C.I.E., D.S.O., for help and constructive criticism.

* This reference is incorrectly given in Seitz, *Grossschmett. Erde*, 9.

SYSTEMATIC NOTES ON BEETLES OF THE SUBFAMILY DYNASTINAE, WITH DESCRIPTIONS OF A FEW NEW SPECIES IN THE BRITISH MUSEUM COLLECTION (COLEOPTERA)

By GILBERT J. ARROW

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WITH PLATE 1.

[Read 18th November, 1936.]

THE preparation of a catalogue of this important group has made it necessary to consider the principles to be adopted and, more particularly, to what extent the numerous new generic names introduced since the publication in 1869 of Gemminger and Harold, *Catalogus Coleopterorum*, 4, often by the partial dismemberment of older genera, can be reconciled with the older names. In the present paper I have given my reasons for regarding as synonyms a good many of the names, of the late T. L. Casey in particular, and I have taken the opportunity of describing various forms which in the course of the work have been found to be without names.

The types are in the British Museum Collection.

In introducing a recent paper dealing with the LUCANIDAE I laid down the principle that, except in certain peculiar cases, genera ought not to be based upon features confined to one sex. In accordance with that principle I proposed to suppress a number of generic names in use in the group. In the DYNASTINAE, as in the LUCANIDAE, a considerable number of generic names have been introduced in which the distinctive features are found in the male alone. A large proportion of the Dynastid genera proposed by Casey in his 1915, *Memoirs on the Coleoptera*, 6, are of this character and such names I consider are best allowed to lapse, so rendering it possible to assign to a genus any specimen of either sex. Apart from the practical inconvenience of being unable to determine female specimens unaccompanied by males, the inconstancy of secondary sexual characters and their liability to disappear in small specimens of a species render them peculiarly unsuitable for the purpose.

For example, *Ligyrodes* Casey is distinguishable from *Ligyrus* only by the form of the front tarsal claws of the male, for "a different general habitus," a phrase much used by Casey, evidently implies a difference too vague for definition and has no diagnostic value.

Anastratus Casey, again, was devised for those species of *Strategus* in which the male is without horns and, although not recognisable in the female sex, is actually referred to a different Tribe from *Strategus*.

Pseudaphonus Casey I regard for the same reason as a synonym of *Cheiroplatys*.

The eight species constituting the genus *Megasoma*, well known as including the largest of existing insects, is said by Casey (1915, *Memoirs on the Coleoptera*, 6 : 259) to include "several genera." As he apparently had a personal acquaintance with only two of the species, he confined himself to diagnosing only two of these genera, *Megasoma* and *Megasominus*, the differential features of which

are those of the males of those two species and are not shared with any of the other six. Unless the species of the present are to become the genera of the future the genus *Megasomius* can hardly be defended.

The difficulties of the cataloguer become greatest in dealing with the various so-called genera into which Casey has divided the large genus *Cyclocephala*. The majority of the species are found in South America and, although, as he proposed to restrict it, most of them are excluded, few of these are or can be distributed among his new genera. He has admitted that these are based largely upon features of the male alone and the acceptance of such names as *Diapatalia*, *Spilosota*, *Ochrosidia*, *Dichromina*, etc., seems to me to involve the replacement of order by disorder. *Dichromina*, which its author considered to be "one of the more distinct and specialised" of his genera, by reason of two features, *viz.* the widely diverging branches of the inner front claw of the male and the very small tarsi, reveals his inadequate knowledge, for there is a group of species (*C. laminata*, *paraguayensis*, etc.) in which the females conform exactly to his diagnosis, while the males, being without the diverging claw, must be excluded from it. Even the name *Aclinidia*, proposed for one of the most isolated species (*C. castanea* F.) depends upon features of the male only and in my opinion is redundant.

It is unfortunate that in the case of one genus which appears to be a sound and useful one Casey has used a name which is not available, *Parachalepus* having been used by Baly in 1885. Casey divided his genus into two subgenera, which he called *Parachalepus* in sp. and *Chalepides*, and it seems best to adopt the latter name as that of the genus. The two subgenera of *Chalepides* are—

- A. *alliaceus* group.
- B. *barbatus* group.

This method of designation appears to me to have decided advantages over the use of subgeneric names (see 1935, *Proc. R. ent. Soc. Lond.*, 10 : 34). The latter are often a hindrance rather than a help to systematic work and, although a large number are of necessity recorded in my catalogue, they are in my opinion without value. Such names are constantly quoted instead of the generic name, causing confusion, they are frequently based upon characters whose presence or absence is significant only in the particular species studied by their author and, although pleasing to him, may be a nuisance to workers in another field. Where characters can be found which are sufficiently definite to diagnose a new genus a new name is justified. When this is not the case, I consider a new name unnecessary and undesirable.

It may, I think, be said that a good deal of Casey's systematic work was regarded by himself as tentative in character. On page 180 of the Memoir in question he says, in diagnosing at considerable length a number of so-called species referred to *Ligyrodes*, "the various taxonomic forms are rather well differentiated and most of those announced below are probably true species." This clearly shows that he was quite prepared for the abandonment of many of his names to synonymy. How large a proportion should be rejected only the careful examination of his types at Washington will reveal, but his method appears to have been to give a new name to every specimen not in all respects typical of any known species, making no allowance for variation, age and wear or abnormality.

Casey also shows a disposition to be greatly influenced, in separating species and genera, by their occurrence in what he regards as different faunistic

areas. It is generally recognised that the geographical range of genera varies enormously and, since it provides the evidence for the solution of many important problems, it is obviously essential that genera, although their limits in many, perhaps in most, cases must be arbitrarily fixed, should in all cases be natural groups, that is that they should be distinguished by anatomical characters alone. Geographical considerations should be allowed no part in the determination of generic limits. Above all, relationships between forms inhabiting different faunistic areas, especially when of an unexpected kind, should not be concealed by the unnecessary use of different names, but, on the contrary, emphasised. It even appears desirable to allow a little more diversity within the limits of a genus composed of species closely related, although inhabiting different regions, than might be considered allowable when all belong to a single confined area.

The very striking and significant affinity between the Tropical American and Australian species united by H. W. Bates under the name of *Cheiroplatys* was rightly emphasised by that eminent Entomologist, who pointed out that no generic distinction had been discovered. Casey has criticised this procedure and again separated the American forms under the name *Orizabus*, suppressed by Bates. The latter referred to the agreement in mouth-structure, without specifically mentioning the maxillae. Casey suggests that the form of the maxillae may justify separation, but it is evident that he made no dissections and had no Australian examples for comparison. Whatever the explanation may be, various genera in different families of beetles are found only in the Neotropical and Australian Regions, e.g., *Syndesus*, in the LUCANIDAE, *Laemosaccus*, in the CURCULIONIDAE, *Heteronyx*, in the MELOLONTHIDAE. The genus *Cheiroplatys* is another of these interesting cases and nothing is gained by obscuring the fact by the use of two generic names where no distinctive feature has been found.

It was evidently on geographical grounds alone that a new name *Dyscinetus ebeninus* was devised by Casey for the Central American specimens referred by Bates to *D. picipes* Burm. He refused to admit the identity of *D. hydrophiloides* Burm. (South Brazil) with the Antillean *D. barbatus* F., and separated another form, *rhomboidalis* Casey, for reasons of colour and size which are quite inadequate when a considerable series is compared. It would perhaps be possible to recognise various local races of this wide-ranging species, but unless better characters can be found than those given, I am unable to see the advantage of multiplying names. In other genera also it is possible that forms to which new specific names have been given by Casey may prove to be actually local races, but this can only be established by a careful study of long series of specimens. The usefulness of attempting to define and name the slight variations in a great continental area of wide-ranging species, of which the materials for an even approximately complete study have never been brought together, is rather more than doubtful.

As an example of his work may be cited Casey's subdivision of the long-familiar *Strategus antaeus* F. into a number of "species" distinguished by depth of colour, sharpness of the external mandibular teeth, and other features affected by wear and degree of maturity. Of these "species" I have seen examples of his *Strategus atrolucens* and *septentrionalis* and these, and in my opinion also his *S. divergens* and *pinorum*, must be regarded as simple synonyms of *Strategus antaeus* F.

Professor Kolbe published in 1910 a dismemberment of the genus *Phileurus* similar to that attempted by Casey for the genus *Cyclocephala*, with the con-

sequent introduction of numerous new generic names. Some of Kolbe's genera rest upon very slight foundations, but in this case all the species were reviewed and no difficulty therefore arises for the catalogue.

The genera *Archophileurus* and *Amblyphileurus* of Kolbe are linked together by an intermediate species to which I have here given the name of *Archophileurus darwini*, and *Periphileurus* Kolbe, distinguished from the two genera just mentioned only by the deep thoracic groove and sharp hind angles to the thorax, is similarly connected by the common species, *Archophileurus ovis* Burm., and in my opinion cannot be maintained. I have therefore united all these under the first name *Archophileurus*.

Lacordaire has remarked (1856, *Gen. Coleopt.* 3 : 446) that the genus *Augosoma* Burmeister (synonymous with *Archon* Kirby), containing only a single African species, is hardly distinct from the Oriental *Xylotrupes* Hope. Of the very slight differential features enumerated the most tangible is the spine-like prolongation of the basal joint of the middle and hind tarsi. A similar spine-like prolongation is found in *Endebius florensis* Lansb. (in the hind legs only in the ♂, but in the four posterior legs of the ♀), an insect inhabiting the Malayan island of Flores, which is so closely related to the typical *Xylotrupes* that, except for the previous separation of the African form, the creation of a third genus would probably not have been contemplated. This insect, by its simple blunt mandibles and fewer maxillary teeth also, shows itself a link with the African form and it seems to me impossible to retain three generic names for three types so closely interrelated. Of the three generic names the oldest is *Archon* Kirby, described in 1825 (*not* 1840, as stated in Gemminger and Harold, 1869, *Cat. Coleopt.*, 4 : 1266). The occurrence in West Africa of an isolated species linked by another in the E. Indian island of Flores to forms distributed throughout the Oriental and Australasian regions, is a remarkable phenomenon. But in Tropical America is found another little group of species, constituting the genus *Dynastes*, equally closely related to the African and Oriental species, and distinguished, in my opinion, by no feature of importance. The mandibles and maxillae alone show slight differences of a similar kind to those distinguishing the Old World forms. It appears to me, therefore, that it accords best with the actual affinities of these insects to place them all in a single genus, *Dynastes*, which will form a fairly well-defined entity, the allied genera, such as *Chalcosoma*, *Golofa*, etc. having features in the mouth-organs, feet, etc. of a distinctly different character.

The insect which has been long familiar under the name *Xylotrupes gideon* L. is very abundant and appears to be found in almost every one of the multitudinous islands of the Indian Ocean and S. Pacific, as well as over a large part of the Asiatic mainland. Over this vast area it shows a marked tendency to develop local differences, most easily noted in the forms assumed by the horns of the males. As these horns are subject to very great individual variation and may be almost entirely absent in small specimens, such differences, being frequently absent, cannot be used diagnostically. Many names have been given by Thomson, Schaufuss and Minck to these local forms. All are no doubt incipient or potential species and, if the communities have been isolated for long periods, some may be quite distinct and separate species. But as the wide area of dispersal shows, this insect is a good traveller, and not, like more sedentary kinds, easily isolated. The acceptance of these island races and local forms as species has the unfortunate consequence of leaving without a specific name a very large number of other equivalent forms, the actual differential characters of which cannot be determined until series of each, including both sexes and

large and small forms of male, have been brought together. Since the first object of all systematic work is to provide the means of conveniently designating any organism when it is desired, I have treated all these numerous forms provisionally as subspecies of a variable wide-ranging species, *Dynastes gideon*, except where comparison of an adequate series of examples has provided unquestionable evidence of a well-defined and separate species. For instance, the form described by Prell as *Xylotrupes meridionalis*, which is abundant in Ceylon, seems to be a well-defined species and is probably completely isolated, for, although found also in Southern India, its genus is apparently absent from the central plains.

To illustrate the illusory results obtained by attempting to base species upon the sexual features without adequate series of examples, I may mention that of all these insects the males with the longest and most strongly forked thoracic horns in the British Museum collection are found amongst a series from the island of New Britain or New Pomerania. Three male specimens, presumably of this race, served as the types of *Xylotrupes lamachus* Minck, diagnosed by the author as having short horns with very short and poorly developed terminal points. In every horned species examples with poorly developed horns are more numerous than those of full development and until very long series have been collected it is not possible to determine what degree of development is characteristic.

Cyclocephalini.

Cyclocephala vinosa sp. n.

Tota rufa, corpore subitus pedibusque inclusis, ovata, nitidissima, pedibus modice gracilibus; clypeo brevi, semicirculari, leviter transverse ruguloso, fronte minute punctato; pronoto toto marginato, impunctato, lateribus fortiter rotundatis, angulis posticis nullis; elytris vix perspicue punctatis; pygidio parce et minute punctato, punctis pilis brevibus erectis instructis:

♀, tibia antica acute tridentata, elytrorum margine externo medio leviter ampliato.
Long. 17 mm.; lat. max. 9 mm.

JAMAICA : Mandeville (C. C. Goudey, Sept.).

In addition to the specimen from Mandeville the Museum contains a second specimen (the type) taken by A. H. Ritchie without precise locality. Both are females and have three very sharp teeth to the front tibia and a slight dilatation of the elytra almost at the middle of the outer margin. The latter widens and again narrows gradually without forming an angle or interrupting the curvature of the side.

This species shows some approach to the genus *Ancognatha*, but the clypeus is very short and the mandibles very blunt.

With the exception of the widely distributed *C. signata* Drury, the Cyclocephalas of the West Indian islands do not seem to be found upon the mainland of America, and most are confined to one island. Two have been recorded from Jamaica, *C. cerea* and *tetrica* of Burmeister. *C. vinosa* is a third species from that island. It is peculiar for its uniform rich red colour and its very glossy surface, which upon the upper side is almost entirely devoid of punctures, with the exception of very fine ones upon the head and pygidium and vestiges of an almost obliterated puncturation upon the elytra. It is rather robust in shape, with the head broad and the clypeus short and semicircular, with a feeble transverse rugosity, the forehead lightly and evenly punctured between the eyes.

The pronotum is entirely margined, the sides evenly rounded, including the obliterated hind angles. The pygidium has fine scattered punctures, which bear pale erect hairs.

Cyclocephala laevis sp. n.

Pallide flava, tarsis vittisque dorsalibus brunneis, pronoto vittis duabus longitudinalibus discoidalibus, singulo elytro vittis tribus obliquis ornato, his nonnunquam deficientibus; elongata, supra laevis, pedibus gracilibus, clypeo sat producto, antice rotundato, fronte minute punctato; pronoto parce et minutissime punctato, lateribus bene arcuatis, antice contractis, angulis posticis obsoletis, basi subtiliter marginato; elytris minute punctatis, punctis partim biseriatis; pygidio parum dense aut longe fulvo-setoso; antennis brevibus:

♂, clypeo longo, fere laevi, opaco, elytris opacis, pedibus anticis crassis, tibia minute bidentata, ungue majori longo, integro:

♀, clypeo leviter ruguloso, elytrorum lateribus paulo ante apicem obtuse angulatis et callosis.

Long. 12-13 mm.; lat. max. 6.5 mm.

SAN DOMINGO: La Romana, Gubimati (July).

A specimen of each sex was taken by Mr. H. E. Box in 1925.

C. laevis is nearly related to the Jamaican *C. tetrica* Burm. and has almost the same colour and pattern. As in that species, the elytra of the male are dull and those of the female shining. It also bears a close resemblance to the common *C. signata* Drury, the elytra of which are shining in both sexes. The upper surface, especially that of the head and prothorax, is smoother than in either of those species. The punctures of head and thorax are exceedingly fine and scanty and those of the elytra rather fine. The pygidium is clothed with pale erect hair in both sexes, not in the male only as in the allied species. The elytra of the female have an obtusely angular thickening of the outer edge, situated much farther back than in *C. signata*. This is not found in *C. tetrica*. The front tibia of the male, as in *C. signata*, bears only two very small terminal teeth and the inner front claw is long and not cleft.

Cyclocephala insulicola sp. n.

Rufa, corpore subitus pedibusque flavibus, capite postice pronotoque nigris sed hujus lateribus pallidis; modice lata, parum elongata, tibiis tarsisque gracilibus, corpore supra nitido, elytris postice setis pallidis nonnullis sparsutis, oculis sat magnis, clypeo angusto, minute ruguloso, antice leviter rotundato, fronte minute haud dense punctato; pronoto minute sat parce punctato, lateribus antice fortiter convergentibus, rectis, postice late rotundatis, angulis posticis nullis; elytris sat crebre haud fortiter punctatis, punctis nonnullis biseriatis; pygidio crebre minute punctato, subopaco:

♂, tibia antica tridentata, dentibus 2 apicalibus valde approximatis, tertio obtuso, tarsorum anticorum ungue interno longo, apice vix perspicue fisso, clava antennali longa.

Long. 13 mm.; lat. max. 7 mm.

LEEWARD Is., W.I.; GUADELOUPE.

Two specimens in the British Museum are both males. This is a dark coloured species with pale legs, like *C. atricolor* Chapin and *nigricollis* Burm. It resembles the latter also in the long antennal club of the male and the clothing of scattered hairs on the elytra. The hairs, however, appear to be much longer and more evident in the North American species, according to Buchanan, and the clypeus of the male broader. This is rather long and narrow in the new form. The whole upper surface is shining, without dull elytra, as in *C. atricolor*,

the punctures of the pronotum fine and scattered and those of the elytra rather strong. The inner front claw of the male, which appears to be entire in both the other species mentioned, is here very long and exceedingly minutely cleft at the extremity.

Dyscinetus laevicollis sp. n.

Niger, nitidus, tarsis antennisque piceis, elongato-ovatus, fere nudus, capite subtiliter ruguloso, margine antico recto, reflexo; pronoto laevissimo, fere impunctato, marginibus lateralibus fortiter arcuatis, angulis anticis acutis, posticis nullis; scutello impunctato; elytris leviter striato-punctatis, seriebus geminatis quatuor serieque suturali, intervallis minute irregulariter punctatis; propygidio longe sat sparse ciliato, antice granulato, postice laevi, pygidio fortiter, basaliter crebre, punctato; metasterni medio laevi, lateribus fortiter punctatis; abdominis medio laevi, lateribus segmentique ultimi parte antica rugulosis; tibiis anticis acute tridentatis:

♂, tarsis anticis crassatis, ungue interiori fisso.

Long. 18-21 mm.; lat. max. 9.5-11 mm.

JAMAICA : Sweet River, Westmorland (*A. H. Ritchie*, Feb.); SAN DOMINGO.

Numerous specimens were taken in Jamaica. The species is recognisable by the extreme smoothness of its pronotum, which is almost completely devoid of punctures, although a few very minute ones can be detected with a lens. The puncturation of the elytra also, although distinct, is very light, but the pygidium is very strongly and, except in its posterior part, rather closely punctured. The propygidium is smooth and shining behind, with a single row of setigerous punctures, but anteriorly it is densely granular and bears a clothing of long but not at all close hairs.

Chalepides punctulatus sp. n.

Niger, nitidus, corpore subtus nonnunquam rufescenti, elongato-ovatus, nudus, propygidio longe ciliato; capite parce et minute punctulato, margine antico fere recto; pronoto parce, medio subtiliter, punctato, margine membranaceo medio paulo producto, lateribus regulariter arcuatis, angulis anticis acutis, posticis nullis; elytris leviter striato-punctatis, seriebus geminatis quatuor serieque suturali, intervallis minute irregulariter punctatis; propygidio crebre punctulato, longe flavociliato, pygidio brevi et laevi; metasterni et abdominis medio laevi, lateribus fortiter haud crebre punctatis:

♂, tibiae anticae dente tertio obtusissimo, tarso antico crasso.

♀, tibia antica acute tridentata.

Long. 19-20 mm.; lat. max. 10 mm.

COLOMBIA.

In this species the pygidium, although very short, is not almost obliterated. It is evidently closely related to the South Brazilian *C. eucephalus* Casey, which is very different in colour. It is also related to *C. dilatatus* Mann., another black form, with a similar puncturation, but it is much smaller than that, and the female of *C. punctulatus* is without the flattened lateral margins of the elytra conspicuous in *C. dilatatus*.

Casey has divided this genus into two and described the typical section (containing *C. barbatus* F., and *hydropilooides* Burm.), as having the pygidium almost of the usual length, while the other has it very short. He was mistaken here, for in the *barbatus* group the pygidium is almost obliterated, as Burmeister has noted, the propygidium having encroached to such an extent that the pygidium is only seen as a narrow lateral band on each side.

Chalcasthenes gen. n.

Brevis, compactus, supra lepidis vestitus. Caput parvum, oculis magnis, prominentibus, clypeo angusto, excavato, antice rotundato. Antennae 9-articulatae. Mandibulæ reductæ, brevissimæ, tectæ, extus haud dentatae. Maxillæ intus 6-dentatae, palpis sat longibus. Labium antice fortiter angustatum, integrum, palpis brevissimis, articulis 2 basalibus transversis. Pronotum latum, angulis anticis et posticis distinctis, obtusis, basi rotundato, haud marginato. Scutellum sat magnum, latum, apice rotundato. Elytra haud striati. Pedes graciles, tibiis anticis tridentatis, posterioribus 4 apice truncatis, paulo dilatatis, tarsis filiformibus; unguibus inaequalibus:

♂, pedum anticorum articulo tarsali 5° paulo crassato, ungue majori late bifido.

Genotype: *Chalcasthenes pulcher* sp. n.

Chalcasthenes pulcher sp. n.

Laete cupreus, elytris nigris, corpore supra et subtus lepidis vel setis albidis parum crebre vestito; breviter ovatus, convexus, supra, clypeo et scutello exceptis, lepidis minutis haud regulariter instructus; capite rugose punctato, clypeo antrorsum angustato, vix bilobato; pronoto parce punctato, punctis lepidiferis, linea mediana fere laevi, scutello nitidissimo, nudo, minute punctulato; elytris irregulariter subrugose punctatis, ubique lepidis modice crebre vestitis; pygidio corporeque subtus sat fortiter punctatis, setis brevibus albidis vestitis, metasterni medio laevigato et profunde sulcato; tibia antica extus tridentata, dentibus 2 apicalibus connatis.

Long. 12.5-13.5 mm.; lat. max. 7-8 mm.

SOLOMON Is.: Ulawa (R. A. Lever, May).

This little insect is probably more nearly related to the very isolated genus *Chalcocrates* than to any other yet known. It has in common with that genus the metallic surface, large prominent eyes, small narrow clypeus, similar mouth-organs and slender tarsi. But in numerous other important respects it differs greatly from *Chalcocrates* and there is no alternative to the formulation for it of a new genus. The peculiar adherent chalky matter forming broad bands upon the elytra of *Chalcocrates* is not present in *Chalcasthenes*, which, almost as unexpectedly, has a clothing of scales, absent, on the upper surface, only from the clypeus, the middle line of the pronotum and the broad scutellum. Scales are found also upon the legs, but they are replaced by short hairs upon the lower surface of the body. The shape of the body is very different, being very short, broad and convex. The antenna consists of nine joints, a single very short one, instead of two, immediately preceding the club, and the latter is rather long in the male. The clypeus is concave, its sides gradually converge from the eyes forward and the front edge is very feebly bilobed. The thorax is not evenly rounded at the sides, as in *Chalcocrates*, but angulated in the middle and convergent to front and rear, with very well marked front and hind angles. The scutellum is very smooth and shining, with strongly rounded sides and very blunt apex. The elytra are irregularly punctured, without trace of striation, and each puncture bears a pale elliptical scale. The propygidium has two longitudinal rows, converging towards the hind margin, of transversely placed tubercles, corresponding with the stridulatory files of *Heteronychus* and other genera. The pygidium has numerous large scale-bearing punctures. The legs are fairly long and slender, the front tibia has two closely-connate blunt teeth at the end and a third at a little distance, the middle and hind tibiae are dilated and feebly crenate, not digitate, at the end, with a strong oblique external carina near the middle. The tarsi are moderately long, but the

male, unlike that of *Chalcocrates*, has the last joint of the front tarsus a little enlarged and its inner claw deeply and widely cleft. The claws of the 4 posterior feet are short and their pulvilli are very short.

***Oryctoderus nanus* sp. n.**

Niger vel rufo-niger, nitidus, corpore subitus breviter griseo-vestito, medio nudo, ovatus, convexus, capite piano, parce et minute punctato, tuberculo minuto utrinque instructo, clypeo haud brevi, antice leviter rotundato; pronoto laevissimo, toto marginato, lateribus medio angulatis, antice convergentibus, postice fere parallelis, angulis anticus acutis, posticis vix obtusis, scutello laevi; elytris parum profunde sed haud minute seriato-punctatis, lateraliter et postice laevigatis, epipleuris nullis; pygidio laevi, piano, opaco, lateribus extremis rugose punctatis, margine apicali longe ciliato:

♂, tibia antica acute bidentata, tarsi antici articulo penultimo intus crebre striato, ultimo magno ungueque interiori longo, minute fiso.

Long. 16-21 mm.; lat. max. 8.5-10.5 mm.

ADMIRALTY Is. : Manus (*N. E. H. Caldwell*).

Only male specimens have been taken.

In certain respects this species links together the genera *Oryctoderus* and *Melanhypus*. It has the well-marked hind angles to the thorax and the flattened pygidium in the male which distinguish the latter genus, but not the depressed bodily shape nor the unnotched mentum. It is much smaller than any yet described species of *Oryctoderus*, and is easily recognisable also by its distinctly but not closely punctured elytra. The pronotum is extremely smooth and shining and the head only bears minute scattered punctures, although these are a little stronger and closer immediately behind the raised front edge. There are also two minute tubercles, far apart, upon the clypeal suture, which is obliterated between them. The sides of the body are rather closely hairy beneath, but the middle is entirely smooth.

***Oryctoderus clypealis* sp. n.**

Niger, nitidissimus, ovatus, convexus, corpore supra glabro, subitus breviter griseo-vestito, medio nudo, capite supra subquadrato, medio depresso, striolato, utrinque tuberculato, clypei margine antico recto, elevato, medio paulo altiori; pronoto laevissimo, lateribus antrorum et retrorum convergentibus, ante angulos posticos paulo sinuatis, his fere rectis; elytris antice parce punctatis, punctis juxta-suturalibus irregularibus, sat fortibus, reliquis subtilibus, partim ordinatis, elytrorum lateribus et apicibus toto laevibus, epipleuris nullis; pygidio brevissime setoso, basi et apice denudatis, margine postico longe ciliato:

♂, pedum anticorum tibia acute bidentata, articulo tarsali penultimo intus crebre striato, ultimo magno, ungue majori apice vix perspicue fiso.

Long. 23 mm.; lat. max. 12 mm.

ADMIRALTY Is. : Manus (*N. E. H. Caldwell*, June).

A single male specimen.

Although I have not seen *Oryctoderus platygenioides* Fairm., it is no doubt closely similar to the present species. *O. clypealis* differs from it, according to description, in the sculpture of the head, which is not punctured but transversely striolate in the middle, in the entirely glossy pronotum, devoid of distinct lateral punctures, and in the very blunt apex of the scutellum (acute in *O. platygenioides*). The sculpture of the elytra appears to be similar to that of Fairmaire's species, the anterior half bearing rather scanty vestiges of a puncturation probably in course of disappearance, all but the punctures near

the suture, which are fairly large, being feeble. These strong punctures are irregularly scattered but most of the remainder form double rows. The pygidium is clothed with very short and inconspicuous hair, which is absent from its base and apex, and the posterior margin bears a fringe of long hairs.

O. platygenioides was assigned by Fairmaire to his genus *Melanhyphus*, but it appears to me to be very doubtfully congeneric with the type species, *M. kleinschmidti*.

Fairmaire also referred to *Melanhyphus* a species from the Philippine Is. which he called *M. semivelutinus*. This I believe to be the insect I recently described as *Peltonotus philippinus*. The two genera are undoubtedly related and lie on the borderland which unites the DYNASTINAE and RUTELINAE, but the Philippine insect, in my opinion, was certainly not rightly placed in the genus *Melanhyphus*. The legs in particular show important differences and those of *semivelutinus* are entirely Ruteline in character. The tarsi are slender, the claws movable and unsymmetrical and the pulvillus small. The tarsi of *Melanhyphus* are short and compact, the claws fixed and equal, and the pulvillus is very long.

ORYCTINI.

Ligyrus herbivorus sp. n.

Nigropiceus, nitidus, subtus rufo-villosus, sat late ovatus, pedibus robustis, tibiis anticis fortiter tridentatis, capite plano, crebre ruguloso, antice attenuato, bidentato; pronoto antice ruguloso, medio et postice parce et minute, lateribus sat fortiter, punctatis, lateribus valde rotundatis, angulis anticis acutis, posticis obtusissimis; scutello laevi, apice paulo impresso; elytris grosse umbilicato-punctatis, punctis seriatis, seriebus haud geminatis, intervallis aequalibus, punctis post-humeralibus et ante-apicalibus irregularibus; pygidii lateribus rugulosis, medio sat minute punctato:

♂, pronoto antice profunde excavato, margine antico medio transversim elevato, cavitate vermiculato-ruguloso, postice medio paulo producto, pygidio convexitissimo.

Long. 14-17.5 mm.; lat. max. 8-10 mm.

BRITISH GUIANA: Georgetown (*C. Williams*, Dec.).

This was found in numbers on the Georgetown Golf Course, and a larva was taken at the roots of the grass. It is a rather short and broad species, with stout legs, and notable especially for the very coarse puncturation of the elytra. The punctures are annular, the centre of each being raised, and are in regular rows, except those behind the shoulders, where the rows become indistinguishable. The pronotum of the male is more deeply and widely excavated than in any other species of the genus known to me, the cavity in large specimens extending half-way to the base, and a slight angle is formed on each side of the middle of its hind margin. There is a blunt transverse elevation at the middle of the front margin. The elevation and cavity are only faintly traceable in the female. The front claws are alike in both sexes.

Bothynus tricornis sp. n.

Pl. 1, fig. 3.

Niger, politissimus, corpore subtus cum pedibus rufescentibus et fulvo-pubescentibus:

♂, pronoto profunde late excavato, margine antico medio antrorum fortiter producto, processu furcato, excavationis lateribus antice oblique productis, processibus compressis, sat latis, apice furcatis, lobis fortiter divergentibus, equalibus.

Long. 31 mm.; lat. max. 18 mm.

S. BRAZIL : Bello Horizonte, Rio Velhao, Minas Geraes (*A. G. N. Chalmers*).

Only a single male example of this interesting form is at present known. It was found in the same locality as the closely related *B. glaucon* Perty (Pl. 1, fig. 2), from which it differs by the occurrence of a third bifurcate horn upon the pronotum, of equal length with the other two. The lateral horns are shorter and broader than those of specimens of *B. glaucon* of similar size, they are not directed straight forward but obliquely upward and their two terminal lobes are equal and strongly divergent. The thoracic excavation is very deep. The legs are very short and stout. The paramera of the aedeagus are slender and without the terminal dilatation of those of *B. glaucon*. In other respects the two forms are exactly similar.

Bothynus cylindricus sp. n.

Rufus, capite, pronoti medio, tibiis tarsisque obscurioribus, corpore subtus pedibusque longe fulvopubescentibus; convexus, cylindricus, fere parallelus, pedibus modice elongatis, tibiis anticis fortiter tridentatis, capite crebre rugoso, antice attenuato, acute bidentato, medio recte carinato; pronoti lateribus sat grosse punctatis, medio postice parce et minute, antice rugoso punctato, hic plus minusve haud late impresso, margine antico tuberculo parvo medio munito, lateribus antice rectis, postice leviter arcuatis, angulis anticis acutis. posticis obtusis; scutello laevi; elytris quadruplici sat fortiter et crebre biseriato-punctatis, intervallis latis, similiter haud regulariter punctatis; pygidio subtiliter transversim striolato, medio parum dense :

♂, pronoti medio profunde haud late excavato, pygidio convexo, sublaevigato, tarsis anticis paulo crassatis, ungue interno late furcato.

Long. 18-19 mm.; lat. max. 10-10.5 mm.

S. BRAZIL : Minas Geraes, Rio de Janeiro (*A. Fry*).

This resembles *B. cibrarius* Fairm. and *laticifex* Burm., but the pygidium is not hairy and the joints of the front tarsi in the male are a little thickened and the inner claw broadly forked. (*B. minor* Steinh. appears also to be similar, but has the vertex of the head smooth and the pronotum broadly hollowed out.) The pronotum has a deep but not wide excavation, which is produced a little in the middle behind. In the female this is represented by a similar but more shallow depression. The pygidium is transversely striolate in the female, but in the male it is almost smooth except at the sides. In other respects the two sexes are alike. The head bears a straight transverse clypeal keel, the pronotum is rugose in the depression and strongly punctured at the sides, and the elytra show four narrow double rows of large, deep and close punctures, with similar but irregular punctures in the intervals.

Bothynus perforatus sp. n.

Piceus, corpore subtus rufescente, haud dense rufohirto; convexus, parum latus, nitidus, pedibus validis, tibiis anticis tridentatis, capite sat laxe rugoso, haud distincte carinato, antice attenuato, vix bifido, pronoto lateraliter haud fortiter, medio laevissime, punctato, lateribus vix rotundatis, medio obtuse angulatis, angulis anticis acutis, posticis obtusis, scutello laevi; elytris brevibus, postice latis, grosse et profunde seriatopunctatis, punctis annulatis, intervallis angustis, fere aequalibus, haud distincte punctatis; pygidio nitido, nudo, lateribus sat fortiter haud crebre punctatis, medio fere laevi, metasterni et abdominis lateribus rugosis, medio laevi :

♂, pronoto antice triangulariter excavato, laxe rugato, margine antico tuberculato; pedum anticorum unguibus aequalibus.

Long. 15-16 mm.; lat. max. 8.5-9 mm.

TRINIDAD; VENEZUELA; COLOMBIA.

The British Museum contains six specimens. In this species there is a deep thoracic excavation in the male but none in the female. The stridulatory area upon the propygidium is less developed than usual in the genus. The fine close ridges are only present near the hind margin of the segment, which is not produced, and become broken up and scattered at a short distance from the margin. The average size is smaller than that of the other known species with the exception of the Patagonian *B. minor* Steinh., a differently sculptured insect, with costate elytra and rugose pygidium. In the present species the elytra bear rather uniform rows of large deep annular punctures, between which the narrow intervals are flat and unpunctured and of almost equal width. The pygidium is shining, very lightly punctured in the middle but more strongly at the sides.

Bothynus laevipennis sp. n.

Rufo-castaneus, capite, pronoto, tibiis tarsisque fere nigris, corpore subtus, metasterni et abdominis medio excepto, pygidioque fulvohirtis, maris autem hujus medio fere denudato: late oblongus, convexus, nitibus, pedibus validis, tibiis anticis tidentatis, capite crebre rugoso, carina debili clypeale leviter arcuata; pronoto profunde et late excavato, margine antico medio tuberculato, lateribus et basi fere laevis, sed prope margines et angulos anticos bene punctatis, angulis posticis late rotundatis, scutello toto laevi; elytris laevis, leviter obsolete lineato-punctatis; pygidio dense transverse strigoso:

♂, pygidii medio denudato, pedum anticorum unguibus aequalibus.

Long. 26-30 mm.; lat. max. 16-18 mm.

S. BRAZIL: Sabara, Bello Horizonte (*A. G. N. Chalmers*); San Paulo.

This is a member of the group to which *B. quadridens* Tasch., *laticifex* Burm., *ascanius* Kirby and *striatellus* Fairm., belong. As in *B. laticifex* the pygidium is very finely strigose and clothed with dense reddish pilosity, although in the male it is almost denuded in the middle. Unlike Burmeister's species, the male has the front claws equal and both sexes have a marginal tubercle to the pronotum. The upper surface is very smooth, with the exception of the closely rugose head and thoracic cavity and the sides of the thorax, which bear fairly strong punctures in the front angles and close to the outer edge. The elytra bear only vestiges of fine punctures, sometimes indicating two or three double lines. The thoracic cavity is very wide and deep in both sexes, its hind margin interrupted in the middle but not produced backward as in *B. ascanius*.

Cheiroplatys laevicollis sp. n.

Niger, nitidus, subcylindricus, corpore subtus piceo, haud dense rufo-hirto; capite brevi, crebre transverse ruguloso, clypeo fere semicirculari; pronoto laevi, lateribus et basi subtiliter parce punctatis, marginibus lateralibus fortiter rotundatis, angulis posticis nullis; elytris fortiter punctato-striatis, lateribus sat irregulariter, apicibus crebre punctatis; pygidio sat crebre et profunde punctato, linea mediana laevi:

♂, pronoti medio rotundatim excavato, cavitate laevi, margine antico leviter acute tuberculato, partis posticæ medio fossa parva praedito, tibia antica lata, apice valde obtuso, margine externo ante medium leviter inciso.

Long. 16.5-18.5 mm.; lat. max. 9.5-10 mm.

NORTH NEW GUINEA: Sattelberg (*Bennigsen*).

One specimen in the British Museum and one in the Deutsches Entomologisches Institut, Berlin Dahlem.

In addition to species from Australia, Central America and the Southern United States, this genus is only known to include one from Norfolk Island and one from New Caledonia. It has not hitherto been recorded from New Guinea.

Although of rather small size, the present insect is evidently fairly nearly related to *C. latipes* and other Australian species. It is distinguished by the smooth pronotum. The head is closely transversely rugulose, the clypeus short and almost semicircular in shape. The thoracic cavity in the male (both specimens belong to that sex) is entirely devoid of punctures, almost round, extending from the front margin, in the middle of which there is a slight pointed tubercle, to well beyond the middle of the pronotum. Behind the cavity is a small but distinct rounded pit and the sides and base of the pronotum bear extremely fine scattered punctures. The elytra are deeply striate, except at the sides and apices, which are irregularly punctured, and the striae bear strong punctures. The pygidium is strongly and rather closely punctured, except along its median line, which is smooth.

Cheiropatrys amphioxus sp. n.

Fusco-rufus, corpore subitus magis rufescens et lateraliter rufohirto; latus, robustus, convexus, politus, capite crebre rugoso, clypeo antice rotundato, a fronte linea recta elevata diviso; pronoto crebre rugoso, lateribus et basi crebre sat minute punctatis, marginibus lateribus antice et postice fere rectis, angulis anticis acute proiectis, posticis obtusissimis, basi leviter rotundato; elytris laevissimis, punctis nonnullis apicalibus serieque suturali leviter impressa instructis; pygidio laevissime irregulariter punctato, lateribus paulo rugulosus:

♂, pronoto profunde excavato, cavitate crebre rugoso, transverse ovali, margine antice et postice medio tuberculato, tibia antica dente obtusissimo munita.

Long. 23-25 mm.; lat. max. 14-15 mm.

QUEENSLAND: Yarraman (A. R. Brimblecombe, Jan.).

Two male specimens, one of them bred in the laboratory.

This is a very well-marked species which appears to differ from all others known by having in the male a tubercle both in front of and behind the thoracic cavity. The latter is very large and deep, extending to within a short distance of the front and hind margins. The elytra are extremely smooth, with only the faintest traces of striae. Even the usually deep sutural stria is represented only by a feebly impressed series of minute punctures. It is a short and stout insect, resembling in some respects *C. excavatus* Lea, but with the sides and base of the pronotum closely punctured. The very blunt tibiae have only a single lateral tooth instead of two.

Papuana philippinica sp. n.

Nigra, nitida, corpore subitus rufo-piceo, parcissime rufo-setoso; elongata, sat angusta, parum convexa; capite laevi, parcissime et subtilissime punctato, tuberculis duobus minutis medio armato; pronoto laevi, haud cornuto aut excavato, lateribus rotundatis, angulis anticis subacutis, posticis obtusis, scutello laevi, lato; elytris fortiter striato-punctatis, stria subsuturali integra, impunctata, reliquis antice et postice abbreviatis, intervallo secundo lato, subtilissime punctato; pygidio crebre et fortiter punctato; tibiis anticis tridentatis.

Long. 19-20 mm.; lat. 10 mm.

PHILIPPINE IS.: Mt. Makiling, Laguna (F. C. Hadden, April, May).

Except for the thickened front tarsi and claws and the longer abdomen of

the male, the two sexes are alike and armed only with a pair of small pointed tubercles placed close together at the boundary of clypeus and forehead. The head and pronotum are very smooth and bear only very minute and scanty punctures. The elytra bear strong rows of punctures, not attaining the front or hind margin.

This species is nearly related to *P. lansbergei* and *P. badia*, but differs from both in having two tubercles instead of one on the head. *P. badia* differs from *P. lansbergei*, in addition to other features, by the thicker clothing of hair on the metasternum, the more rounded sides of the pronotum and its more pronounced hind angles, especially in the male.

Prof. Prell has suggested that *Metanastes* may be synonymous with *Papuana*, but the triangular clypeus like that of *Heteronychus* and differently shaped mandibles show that this is not so.

Dipelicus trifidus sp. n.

Niger, vel piceo-niger, glaberrimus, subitus cum pedibus rufus, fulvo-villosus; subcylindricus, valde convexus, capite antice verticali, utrinque acute angulato, supra cornuto; pronoto medio valde dilatato, angulis omnibus obtusis; elytris modice elongatis, postice vix dilatatis, stria juxta-suturali impressis, marginibus posticis leviter subrugosis; pygidii lateribus leviter subrugosis, medio glabro :

♂, capite cornu acuto, retrorsum curvato armato, pronoto late et profunde excavato, cavitate carina acuta delimitata, hac medio antrorum producta, bifida, tuberculo erecto instructa :

♀, capite supra bilobato.

Long. 30-32 mm.; lat. max. 16-17 mm.

BRITISH NEW GUINEA : Yule I. (R. V. Oldham, Nov.).

This new species is closely related to *D. quadrifidus* Fairm. (renamed *alveolatus* Hell. in 1897 and probably the same as the earlier named *nasutus* Bates, described from a single female mistaken by Bates for a male).

The pronotum of the male, instead of a central horn flanked by a shorter process on each side, as in that species, bears a bifurcate median process directed forward, with an erect tubercle upon it near its base. The thoracic cavity is very deep and wide, extending in well-developed specimens to the front angles, from which a very sharp enclosing ridge extends to the dorsal horn. The entire upper surface, as in the allied species, is extremely smooth. The pronotum in both sexes is more angularly dilated at the sides than that of *D. quadrifidus*, and its hind angles are very obtuse but not rounded off. The elytra are a little longer and more parallel-sided, not appreciably dilating behind.

Dipelicus salomonensis sp. n.

Ferrugineo-rufus, glaberrimus, subitus paulo pallidior, rufo-villosus; ovatus, convexus, capite antice verticali, utrinque obtuse angulato, margine antico leviter bilobato; pronoto impunctato, lateribus valde rotundatis, angulis anticis haud acutis, posticis valde obtusis, basi trisinuato; scutello laevi; elytris fere impunctatis, postice leviter ampliatis, stria juxta-suturali sat fortiter impressis, apicibus leviter rugulosis, pygidio brevi, laevissimo; pedibus brevibus, tarsis sat gracilibus, pedum posticorum articulo basali quam latitudinem paulo longiori :

♂, capite cornu acuto brevi armato, pronoto antice late excavato, cavitatis margine postico trituberculato, tuberculis lateralibus obsolescentibus :

♀, capitis carina supra laevissime emarginata.

Long. 25-31 mm.; lat. max. 13-15 mm.

SOLOMON IS. : Bougainville, Kieta (*J. L. Froggatt*, March); San Cristobal.

This is a rather light coloured and very glossy species closely resembling *D. quadratifer* Hell., but the thoracic cavity in the male is strongly transverse, confined to the anterior half of the pronotum and not limited at the sides by a ridge as in that species. The narrow rugulose posterior margin of the thorax is also absent. The stridulatory area extends to the hind margin of the propygidium and the tarsi, especially those of the middle legs, are a little longer than those of *D. quadratifer*.

D. salomonensis is also closely related to *D. integriceps* Fairm. with the type of which, in the Paris Museum, it has been kindly compared for me by Monsieur Lesne. The upper surface is smoother than that of *integriceps*, the pronotum is without the punctures and plications near the front margin on each side and the elytra are devoid of the linear series of granules found in Fairmaire's species. In the latter the lateral tubercles of the male pronotum are absent and the median tubercle is longer and sharper.

Temnorrhynchus.

The species of this genus are confined to Africa and Madagascar, with one exception, *T. baal* Reiche. This was originally recorded from Syria, but it has a wide range extending from Macedonia to Central Arabia and the Sudan. African examples were redescribed by Fairmaire under the name *T. sennariensis*.

One species of the genus, known by many different names, is very abundant in Africa. I referred to it in 1908 as *T. antiochus* Fairm. As *T. diana* Beauv., Kolbe gave names to four local phases of it. But the oldest name is *coronatus* F., the type of which, a rather worn female specimen in the British Museum, was supposed by Fabricius to have come from Java. Peringuey described the species again as *T. faunus*.

Although extremely closely related to *T. coronatus* F., it seems justifiable to regard the pale coloured West African form here described as a distinct species.

Temnorrhynchus flavipennis sp. n.

Rufo-flavus, capite, pronoto, tibiis partim tarsisque infuscatis; cylindricus, modice elongatus, capite transverse ruguloso; pronoto grosse rugoso, scutello laevi; elytris sat nitidis, minute parum profunde punctatis, seriebus geminatis tribus indistinctis, lateribus impunctatis; pygidio laevi, punctis piliferis prope basin sparsutis:

♂, capite supra acute bicornuto; pronoti dimidio antico sat profunde rotundatim excavato, cavitatis margine postico medio acute tuberculato.

Long. 18-23 mm.; lat. max. 9-13 mm.

N. NIGERIA : Bagana (*W. Scott Macfie*, Jan.).

S. NIGERIA : Onitsha (*J. A. de Gaye*, July), Asaba.

Six specimens are all males.

The bright yellow elytra and lower surface, contrasted with the dark head and pronotum, distinguish this at first sight from all other known forms. In other respects it is not easily separable from *T. coronatus*. The cavity of the male thorax is deeper and scarcely extends beyond the middle of the pronotum, whereas in all but very poorly developed males of the common species it extends farther back. The paramera of the aedeagus in *T. flavipennis* taper gradually and evenly from the base to near the apices, where they swell into pear-shaped tips. In *T. coronatus* although the aedeagus is not constant in shape, the basal part of the paramera is shorter, the dilated apices are larger and the narrowest part is near the middle.

Temnorrhynchus elongatus sp. n.

Rufo-niger vel fusco-rufus, corpore subitus pedibusque rufis, cylindricus, sat angustus, politus, capite leviter transverse ruguloso, supra late, haud fortiter aut acute emarginato; pronoti lateribus grosse rugosis, medio laevi; elytris politissimis, stria utrinque suturali; pygidio medio granulis setiferis haud crebre praedito, basi et apice laevigatis; pedibus posticis crassissimis, tarsis calcaribusque tibialibus latissimis:

♂, capite supra utrinque angulato, vix cornuto, pronoto antice paulo excavato, cavitatis margine postico medio minute tuberculato:

♀, capite supra haud utrinque angulato.

Long. 20-22 mm.; lat. max. 11 mm.

S. AFRICA, PONDOLAND: Port St. John (*R. E. Turner*).

This species is distinctly more elongate than most of its congeners and the elytra are extremely smooth and glossy. It is nearly related to *T. clypeatus* Kl. and *coronatus* F., but is of a narrower shape than the former and the spurs of the hind tibia are more broadly dilated. *T. coronatus* F., of which the type (a female) is in the British Museum collection, differs in the sculpture of the upper surface. The head of *T. elongatus* is lightly and transversely rugulose, its upper margin very bluntly excised. That of *T. coronatus* is deeply sculptured and distinctly punctured in the posterior part. The posterior excision is much deeper. The pronotum of the new species is coarsely rugose, without punctures, and smooth in the middle. That of *T. coronatus* is distinctly punctured in the middle and coarsely pitted at the sides.

Temnorrhynchus erectilobus sp. n.

Castaneus, nitidus, capite pronotoque paulo obscurioribus, ovalis, haud glaber, capite antice crebre rugoso, supra arcuatim emarginato; pronoti lateribus crasse rugosis, scutello lato, laevi; elytris distincte sed haud profunde striato-punctatis, striis geminatis, postice oboletis, intervallis leviter punctatis; pygidio antice et postice sublaevi, medio granulis setiferis nonnullis praedito:

♂, capite acute bicornuto, cornubus parallelis, pronoto medio parum profunde excavato, cavitate postice carina longitudinali divisa, illius margine postico tuberculo erecto armato.

♀, pronoti medio fortiter punctato.

Long. 20 mm.; lat. max. 11-11.5 mm.

MADAGASCAR: Nossi-bé.

The British Museum contains a specimen of each sex.

Four species of the genus *Temnorrhynchus* are at present known to inhabit Madagascar. Three of them are extremely smooth and one, *T. grandicornis* Fairm., has the pronotum entirely smooth and the elytra strongly punctured. *T. erectilobus* has the pronotum coarsely rugose at the sides and punctured in the middle (at the base only in the male) and the elytra punctured. The pygidium is rather smooth, with a horizontal series of scanty setigerous granules across the middle. The head-plate is strongly rugose and roundly emarginate above. In the male it is produced into short but sharp horns, and the thoracic excavation is not very deep but is divided behind by a longitudinal ridge. The tubercle in the middle of the hind margin of the cavity in this sex is strong and erect.

Dichodontus punctipennis sp. n.

Pl. 1, fig. 1.

Niger, sat nitidus, subtus rufo-hirsutus; robustus, pronoto grosse punctato-rugoso, postice medio fere laevi, lateribus medio obtuse augulatis, deinde antrorum convergentibus,

rectis, postice parallelis, fere rectis, elytris fortiter punctatis, punctis partim in lineis geminatis ordinatis :

♂, capite cornu longo, simplici, valde arcuato armato; pronoto postice elevatione lato, antice truncato, paulo producto munito, parte retusa antica medio laevi; pygidii basi et lateribus sat subtiliter rugosis, medio inaequaliter punctato :

♀, capite postice tuberculato, pronoto crebre rugoso, antice vage impresso; pygidio aequaliter et subtiliter rugoso.

Long. 27-33 mm.; lat. 16-18 mm.

MALAY PENINSULA : Perak, Taiping (C. Wray), Penang (G. E. Bryant, Oct.).

This species is easily distinguished by its strongly, although not very deeply, punctured elytra. It is rather elongate and parallel-sided. The pronotum is not very wide, its sides are rounded in the middle, not abruptly angulate, and nearly straight to the front and hind angles. The female has a small tubercle upon the head and a very slight depression, without any definite margin, at the front of the pronotum. The male is armed with a long cephalic horn and the thoracic hump is only feebly produced and broadly truncate at its front margin.

Prell has maintained (1912, *Coleopt. Runds.*, 1 : 103) that the Sumatran, Bornean and continental examples, which I refer to *D. coronatus* Burm., constitute three separate species, and has introduced a new name, *angulatus*, for the first. The T-shaped aedeagus of the male, which appeared to him sufficient to distinguish this, is in reality characteristic of *D. coronatus* throughout its range.

Oryctes capucinus sp. n.

Pl. 1, figs. 7 & 8.

Rufopiceus, capite pronotoque nigris; robustus, nitidissimus, corpore subtus parce et breviter setoso, clypeo antice late emarginato, prothorace antice valde attenuato, elytris politis, haud angustis, dimidio interiori stria punctata punctisque minutis haud profundis praedito, dimidio exteriori subtilissime punctato; tibia antica tridentata, media et postica apice bidentatis :

♂, capite rugoso, cornu longo, fortiter recurvo, compresso, apice acuminato armato; pronoti lateribus antice rectis, convergentibus, angulis sat acutis, postice leviter rotundatis, angulis obtusis, dorso postice nitido, valde elevato, medio triangulariter producto, parte antica tota retusa, crebre rugosa, basi trisinuato, anguste rugoso; pygidio convexo, polito, basi anguste ruguloso et setoso.

Long. 50 mm.; lat. max. 24 mm.

PORTUGUESE CONGO : Caconda (R. Swainson-Hall).

I have seen only a single male specimen. The species differs from all others known to me in the triangular process from the strongly elevated posterior part of the thorax. The body is rather smooth and shining above and beneath, the hairy clothing of the lower surface very short and scanty. The cephalic horn is long, strongly curved, sharply pointed and punctured or rugose. The pointed thoracic process is very smooth and shining and extends well past the middle of the thorax. It is deeply hollowed beneath and there, like the whole anterior part of the pronotum, closely rugulose. The elytra are very smooth and shining, with fine scattered punctures, parallel-sided but not very elongate.

A female specimen of *Oryctes tarandus* Oliv. in the British Museum bears the name "Juba" in the handwriting of Kirby, and the label is in all probability that of the latter's original specimen of *Scarabaeus juba* (1818, *Trans. linn. Soc. Lond.*, 12 : 459). The description, however, does not apply to the

Oryctes and seems to indicate that the type, which should be found in the Museum collection but appears to be lost, was a specimen of *Dasygnathus australis* Boisd., which name must be superseded by Kirby's.

Coelosis denticornis sp. n.

Pl. 1, figs. 5 & 6.

Rufo-castaneus, sat nitidus, modice latus, capite rugoso, antice vix bidentatus, mandibulis latis, extus leviter crenatis haud dentatis; pronoti dorso minute, lateribus fortiter et rugose punctatis, marginibus lateralibus valde rotundatis, antice fere rectis, angulis anticis acutis, posticis obtusis; elytris minute seriato-punctatis, vix striatis, intervallis parce minutissime punctulatis; pygidio crebre ruguloso;

♂, capite cornu recurvo, postice unidentato, armato; pronoto medio excavato, excavationis margine postico carinato, utrinque antrorum producto, fundo antice parce punctato, nitido, postice crebre ruguloso; pygidio leviter ruguloso, nudo;

♀, capite postice minute tuberculato; pronoto toto convexo; pygidio minute ruguloso, breviter sat dense rufo-hirto.

Long. 28-33 mm.; lat. max. 15.5-18 mm.

ARGENTINA: Villa Ana, Santa Fé Prov. (K. J. Hayward, Jan.-Apr.), Corrientes.

This has the general form of *C. bicornis* F., but the surface is more smooth and shining and the puncturation finer. The mandibles are not dentate, as in that species, and the clypeus is not distinctly cleft at the apex. The punctures of pronotum and elytra are finer and the latter are not distinctly striate, although there are regular lines of punctures. The legs are rather stouter and the teeth of the front tibiae are much shorter.

In the male the cephalic horn has a sharp tooth behind. In *C. bicornis* there is a slight posterior flange present in very large specimens only. The thoracic cavity in that species is coarsely punctured, but in *C. denticornis* it is rather sparingly punctured in the middle and closely rugulose behind and at the sides.

Coelosis nitidus sp. n.

Rufo-castaneus, nitidus, modice latus, capite rugoso, antice acute bidentato, mandibulis extus fortiter tridentatis; pronoti dorso minute, lateribus fortiter rugoso punctatis, marginibus lateralibus rotundatis, antice leviter sinuatis, angulis anticis acutis, posticis obtusis; elytris leviter striatis, striis minute punctatis; pygidio crebre ruguloso:

♂, capite cornu recurvo, valde arcuato, haud dentato, armato; pronoto medio excavato, excavationis margine postico carinato, utrinque antrorum producto, fundo antice punctato, postice toto laevi.

Long. 27 mm.; lat. max. 14 mm.

ARGENTINA: Estancia Biscacheras, Entre Ríos (G. E. Bryant, Jan.).

A single male specimen was found.

C. nitidus is very nearly related to *C. denticornis*, and, like it, is smoother and more shining than the other species of the genus. It differs in its sharply toothed mandibles, the acutely bidentate clypeus, the cephalic horn of the male not toothed behind and the very smooth and shining posterior part of the thoracic cavity in the same sex. The elytra are still more shining than those of *C. denticornis*. The aedeagus is conspicuously different in shape, the paramera being very narrow and parallel for a short distance from the tip, the sides then strongly diverging. In *C. denticornis* they dilate regularly but very feebly from apex to base.

Phileurini.

Although numerous species of *Cryptodus* have been described, the constant external difference between the sexes has usually been overlooked. The sexes can be easily distinguished by the shape of the pygidium. In the male it is always convex, the abdomen is correspondingly shortened beneath, the last sternite not produced and sometimes a little emarginate. In the female, the pygidium is rather flat and the last sternite is more or less pointed at the end. *C. costulipennis* and *fraternus* of Fairmaire, of which M. Oberthür has kindly lent me the types, are ♂ and ♀ respectively of a single species.

The genus has three well-marked sections—A, the most numerous, in which the mentum is strongly excised at its hind margin forming two pointed processes; B, in which the mentum is straight, slightly rounded or only feebly excised behind, the two pointed processes absent, and C, in which the mentum bears a prominent rounded lobe behind. In section B, the males, in addition to the convex pygidium, have the front tarsi modified. They are short and thick and the inner claw is dilated, bent and furnished with a broad lobe at the base. In sections A and C the tarsi are usually alike in both sexes, but *C. concentricus* Lea, belonging to section A, forms a link with section B, having the front tarsi of the male modified.

The two following species belong to section B. It is not impossible that they may ultimately be found to be local forms of one wide-ranging species, *C. tasmaniensis* Westw., but the numerous typical examples of that examined appear to show that it is confined to Tasmania and Victoria.

Cryptodus reginae sp. n.

Niger, nitidus, corpore subtus pygidioque rufopiceis; paulo depresso, elongatus, capite ubique haud dense transversim ruguloso, leviter bitumiduloso, margine antico fere recto; pronoto sat fortiter et sparsim punctato, medio anguste sulcato, lateribus antice et postice contractis, fere rectis, angulis anticis acutis, posticis obtusis; elytris sat crebre varioloso-punctatis, utroque costis tribus vix elevatis praedito, interstitiis haud punctulatis; pygidio haud dense transversim ruguloso, apice fortiter punctato; corpore subtus ubique vermiculato-ruguloso, mento postice rotundato; tibiis anticis tridentatis:

♂, pygidio valde convexo, tarsis anticis crassatis, ungue interno valde inflexo, lato, basi lobo ovali praedito.

Long. 21-22 mm.; lat. max. 10-11 mm.

QUEENSLAND.

A specimen of each sex was taken during the voyage of H.M.S. "Challenger."

Nearly related to *C. tasmaniensis* Westw. and *C. ater* Lea and of similar appearance, rather broad and flat, with shining black upper surface, but the lower surface is deep red. It differs from *C. ater* in having the mentum entire behind and not excised, from *C. tasmaniensis* in having larger and rather less numerous punctures upon the pronotum and elytra and the pygidium closely reticulate and not punctured, and from both in having distinct, though obtuse, hind angles to the pronotum. The scape of the antenna is sharply triangular, as in *C. tasmaniensis*. The thickened front tarsi and lobed inner claw of the male are also practically of the same form. The lower surface is rather closely sculptured.

Cryptodus elongatus sp. n.

Niger, nitidus, angustus, paulo depresso, capite sat crebre transversim ruguloso, medio late impresso, leviter bituberculato, margine antico fere recto; pronoto parum fortiter aut

crebre punctato, medio anguste sulcato, lateribus antice contractis, fere rectis, angulis acutis, postice leviter arcuatis, angulis rotundatis; elytris sat crebre varioloso-punctatis, utroque costis tribus angustis paulo elevatis praedito, interstitiis haud punctulatis; pygidio crebre transversim ruguloso, apice fortiter punctato; metasterno grosse punctato, abdominis subtus medio parce punctato, lateribus rugulosis, mento crebre punctato, postice rotundato; tibiis anticis tridentatis:

♂, pygidio valde convexo, tarsis anticis crassis, ungue interiori valde inflexo, lato, basi lobo rotundato praedito.

Long. 17-18 mm.; lat. max. 7-8 mm.

NEW SOUTH WALES ; VICTORIA.

C. elongatus closely resembles *C. reginae* and *tasmaniensis*, but is smaller and relatively narrower than either. The sculpture of the upper surface is almost the same, but the punctures of the pronotum are rather larger and fewer than in *C. tasmaniensis*. The hind angles are rounded, as in that species. The metasternum and abdomen are closely rugulose at the sides and finely, not closely, punctured in the middle.

The male, as in the allied species, has the front tarsi thickened and the inner claw strongly bent and broadly lobed at the base.

I recorded in 1908 reasons for attributing the name *Phileurus verrex* to an Argentine species and described as *P. burmeisteri* the Brazilian form supposed by Burmeister to be the female of this species. Kolbe has since published further remarks upon the form "in Argentina and Montevideo" which he regards as Burmeister's species, including a description of the aedeagus. He was evidently unaware that there are two closely similar Argentine species, in one of which the pygidium is much smoother than in the other and the pronotum much less punctured. Burmeister's expressions "bis zur Mitte punktierten Seitenhalften" and "Afterdecke glatt" seem clearly to indicate the former, which is found commonly at Montevideo and Buenos Ayres, while the aedeagus described by Kolbe is that of the latter, which I propose to name *Archophileurus santafeanus*. The aedeagus of the true *A. verrex* is entirely different and of simple tubular shape. It is parallel-sided, smooth and evenly rounded, the paramera not keeled at the suture nor sharply produced at the tip. The three species may be distinguished as follows:—

- 1(4). Pygidium swollen in the basal part in both sexes, not very coarsely punctured.
- 2(3). Pygidium very smooth in the middle, lightly punctured at the sides: sides of pronotum finely punctured in the anterior half; ♂, aedeagus with the paramera not separated, parallel-sided *verrrex* Burm.
- 3(2). Pygidium rather evenly but not coarsely punctured; sides of pronotum strongly punctured to beyond the middle; ♂, aedeagus keeled, paramera not separated, dilated behind *santafeanus* sp. n.
- 4(1). Pygidium gently and uniformly convex in both sexes, very coarsely punctured; ♂, aedeagus with the paramera widely separated in front *burmeisteri* Arr.

***Archophileurus santafeanus* sp. n.**

Niger vel piceo-niger, nitidus, corpore subtus cum pedibus rufovilloso, subcylindricus, haud depresso, capite antice acuminato, reflexo, pronoto medio sulcato, antice haud minute punctato, post medium laevi; elytris fortiter punctato-striatis, postice confuse punctatis; pygidio sat equaliter haud fortiter punctato, basi tumido:

♂, capite bicornuto, pronoto antice rotundatim excavato; pygidio convexo:
 ♀, capite bituberculato, pronoto anguste sulcato, pygidio basi valde tumido.
 Long. 16-22 mm.; lat. max. 9-11.5 mm.

ARGENTINA: Villa Valeria, Sta Elena, Entre Ríos, Rio San Javier, Santa Fé
 (G. E. Bryant, Dec., Jan.).

***Archophileurus darwini* sp. n.**

Rufo-piceus, pedibus longe fulvopilosus; ovatus, convexus, nitidus, capite rugoso, utrinque transversim carinato, clypeo ruguloso, breviter acuminato, apice reflexo; pronoto nitido, parco et minute punctato, dorso haud sulcato, lateribus antice fere rectis, postice arcuatis, angulis posticis nullis, scutello fere semicirculari, laevi; elytris profunde scriato-punctatis, serie suturali postice striata, aliis abbreviatis, intervallis laevibus; pygidio polito, punctis minutis nonnullis piliferis; metasterni medio laevi, lateribus punctatis, breviter fulvopilosus; pedibus brevissimis, robustis, tibia antica fortiter tridentata, posterioribus 4 apice late truncatis.

Long. 12 mm.; lat. max. 6 mm.

URUGUAY: Maldonado (*Charles Darwin*).

A single male specimen of this small species was taken by Darwin during the voyage of the "Beagle" one hundred years ago, and is the only example known to me. It is similar in size and shape to *A. fimbriatus* Burm. but broader, with shorter and stouter legs and very smooth pronotum, bearing only fine, scanty punctures and entirely devoid of median groove. The elytra also are rather smooth, but bear rows of punctures, which are of moderate size upon the anterior half, disappearing upon the posterior half laterally and a little farther back dorsally, except the sutural series, which attains the apex in the form of a deep stria. The pygidium is very smooth, but has a very few minute punctures carrying fine erect hairs.

The genus *Archophileurus* was introduced by Kolbe for two species, *A. cribrosus* Lec. and *fimbriatus* Burm., and distinguished from *Amblyphileurus* only by having blunt mandibles and pronotum without or almost without a median groove. The new species has the pronotum entirely without a groove and the head, as in the typical *A. cribrosus*, bears two transverse ridges. On the other hand the mandibles are acute, as in *Amblyphileurus*, so that there is a link between the two groups and it appears to me necessary to unite them under the first name.

***Hemiphileurus*.**

Hemiphileurus cylindroides Bates, ranges, according to Bates, from Honduras to Panama. But the specimens studied by him actually belong to two closely related species, of which one, including the example from Rio Susio selected as typical and figured by the author, appears to be confined to Costa Rica. The more wide-ranging form is less coarsely punctured and may be called ***H. fraternus* sp. n.** The two species may be distinguished as follows:—

Pronotum coarsely and equally punctured, with broad median groove; elytra very coarsely and closely punctured; hind tibia with long lateral spine; ♀, pygidium coarsely punctured; ♂, aedeagus feebly dilated behind. Costa Rica *cylindroides* Bates.

Pronotum more finely punctured, smooth behind, with narrow median groove; elytra less coarsely punctured, hind tibia with short lateral spine; ♀, pygidium densely rugose; ♂, aedeagus broadly dilated behind. Honduras to Panama *fraternus* sp. n.

Homophileurus paraguayanus sp. n.

Niger, nitidus, compactus, convexus, haud deplanatus, capite rugoso, antice acuminato, reflexo, vix producto, cornubus lateralibus marginalibus, rectis, acuminatis, parte postica profunde excavato; pronoto antice retuso, modice punctato, margine superiori bituberculato, postice laevi, profunde sulcato, sulco, area utrinque antica discoidalii angulisque anticus grosse subrugose punctatis, angulis anticus acutis, lateribus fortiter rotundatis, angulis posticus obsoletis; elytris brevissimis, grosse et profunde punctato-striatis, apicibus fortiter haud seriatim punctatis; pygidio laevi, parce et minute punctato; metasterni medio laevi, lateribus grosse et crebre punctatis; abdomine subtus laevi, segmenti ultimi basi ruguloso.

Long. 25-26 mm.; lat. max. 12.5-13.5 mm.

PARAGUAY: Asuncion (E. G. Kent).

This species represents the farthest extension known southwards of the genus *Homophileurus*, most of its members being found north of the Equator. It is a small, short and compact form, with short, pointed and erect marginal horns and sharp but very short apical angle to the head. It nearly resembles *H. 4-tuberculatus* Beauv., but is shorter and more convex. The legs are stout, the front tibiae broad and distinctly 4-dentate. The upper margin of the retuse anterior part of the pronotum bears only two tubercles and the hind angles of the prothorax are completely rounded off. The pronotum is very deeply grooved, the elytra bear large annular punctures in deep striae and the pygidium is convex and finely punctured.

The two sexes differ little, but the last ventral sternite is shorter in the male.

Actinobolus angustus sp. n.

Pl. 1, fig. 4.

Rufo-piceus, capite tarsisque fere nigris, elongatus, subcylindricus, convexus, nitidus, capite punctato-rugoso, clypei margine fortiter reflexo, quinque-lobato; pronoto antice crebre punctato-rugoso, postice parce punctato, medio sulcato, sulco rugoso punctato, antice obliterato, lateribus fortiter rotundatis, antice rectis, angulis anticus acutis; elytris sat fortiter punctato-striatio, pygidii basi sat minute punctato, apice laevi, metasterno subtiliter punctato, dense haud longe rufo-villoso; tibia antica dentibus tribus fortissimis quorum apicali longo quartoque minuto armata:

♂, abdominis segmento ultimo ventrali brevi.

♀, " " " " " trianguli.

Long. 23 mm.; lat. 10.5 mm.

S. BRAZIL: S. Paulo (A. Fry), Montevade (E. Luja), Mus. Luxemburg.

A. angustus is a little more elongate and cylindrical than *A. radians* Westw., pitchy-black in colour and very shining. The pygidium in both sexes is very smooth and shining upon its apical half, with rather scattered and not very large punctures in the anterior half.

In describing *Actinobolus talpipes*, Ohaus has indicated his type as a female. It appears to me probable that it is a male, but that Ohaus, not finding the marks of that sex usually to be found in the DYNASTINAE, assumed it to be a female. In this group the sexes differ little and the last ventral segment of the male is not excised, although shorter than that of the female.

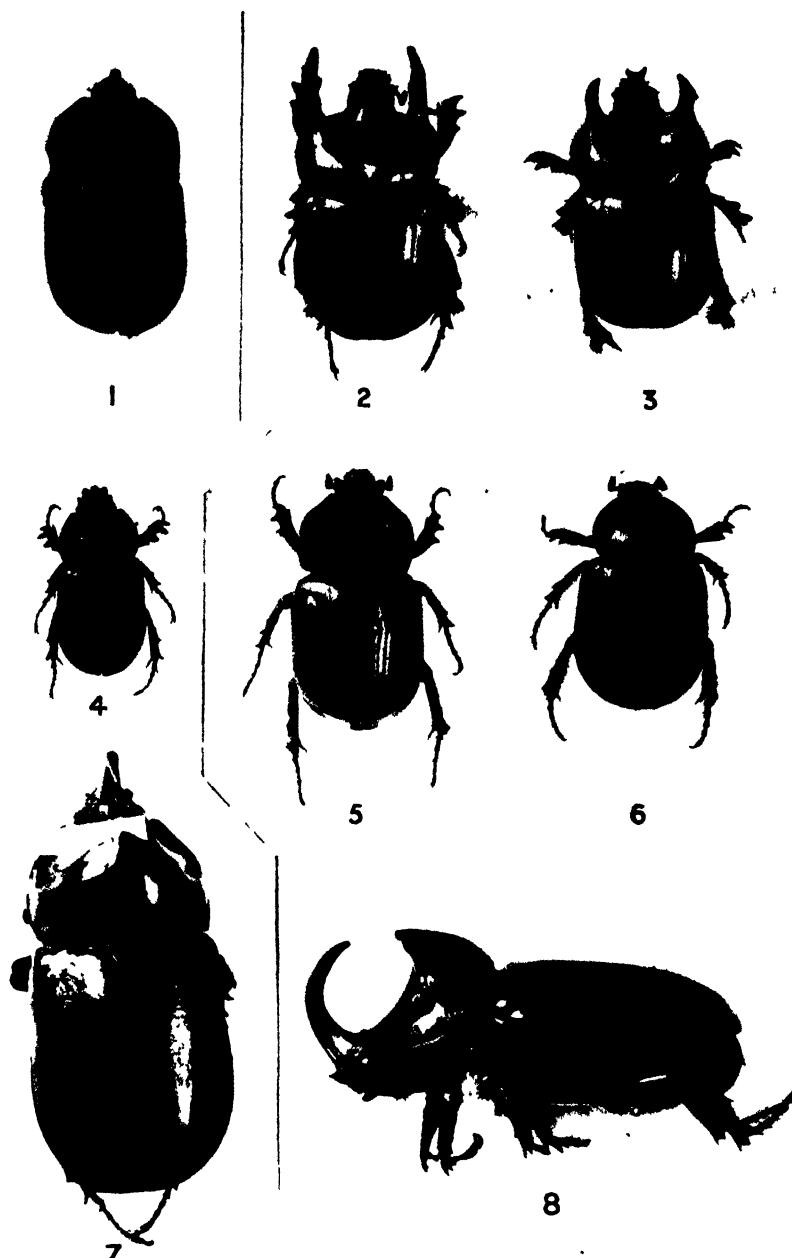
The type of *A. talpipes* is described as having the propygidium and pygidium closely covered with coarse annular punctures, but a female specimen in the British Museum, agreeing with the description in all other respects, has the

pygidium very smooth, with a few fine punctures in the anterior angles only. The type of *A. radians* Westw. and a specimen of the same species in the British Museum collection are female and male respectively. In the former the abdomen is convex beneath, the hinder edge of the last segment is uniformly rounded and the pygidium is finely punctured on its anterior half and smooth and shining at the apex. In the male the abdomen is contracted and arched, the last segment is a little truncated and the pygidium coarsely punctured from base to apex.

EXPLANATION OF PLATE 1.

- FIG. 1. *Dichodontus punctipennis* sp. n., male.
2. *Bothynus glaucon* Perty, male.
3. *B. tricornis* sp. n., male.
4. *Actinobolus angustus* sp. n.
5. *Coelosis denticornis* sp. n., male.
6. *ditto*, female.
7. *Oryctes capucinus* sp. n., male.
8. *ditto*, lateral view.

All figures are natural size.



ENGRAVED BY STAR ILLUSTRATION LONDON.

Dynastine Coleoptera. Natural size.

NEW AFRICAN LYCAENIDAE AND NYMPHALIDAE, AND TWO
NEW *DIESTOGYNA* (LEPIDOPTERA.)

By G. TALBOT.

WITH PLATES 1-2.

THE species here described represent chiefly some further discoveries made by Mr. T. H. E. Jackson; other novelties obtained by him were described by myself in 1935 (*Ent. mon. Mag.*, 71).

I am indebted to Mr. Jackson for directing my attention to the possible novelties, examples of which in some cases existed already in the British Museum. In the latter case the type has usually been selected from that material; in the other case Mr. Jackson has presented the type to the British Museum collection. Unless otherwise stated the types and other specimens are in the British Museum.

I am indebted to Professor G. D. Hale Carpenter for permitting me to compare specimens in the Hope Department at Oxford.

LYCAENIDAE.

LIPTENINAE.

1. *Telipna sanguinea* Ploetz *depuncta* subsp. n.

The Uganda race of this species differs especially in its paler colouring, in the reduced black borders on the underside, and in the absence of the black basal spot on the hind-wing below.

♂. *Upperside* paler red. Fore wing red area in most specimens extended a little beyond end of cell, leaving a black discocellular mark; this is rarely the case in the nominotypical form. The red area is further extended in areas 2 and 3, and comes very near the margin between vein 2 and the tornus. The posterior spot of the three which form the subapical band is very much smaller than either of the other two. Hind-wing with narrow black borders, being about 3.5 mm. wide on vein 3 as against about 5.5 mm. in the nominotypical form. *Underside* paler than above, more ochraceous. Fore-wing with narrower black costal spots and bars, and a broad spur of the ground-colour beyond end of cell. White subapical spots as above but larger. Distally of these the area of ground-colour is usually wider and extends closer to the apex than in the nominotypical form, whilst its outer edge almost reaches the margin, and is not indented. Hind-wing without a black costal spot. White discal band wider, reaching vein 5; in the nominotypical form it is not defined below vein 6. The black marginal border narrow as on the upperside.

♀. Resembles the ♂, but with paler and more ochraceous colouring. The white subapical band with posterior spot small as in the ♂. Underside as in the ♂.

Hab.—UGANDA: Tero Forest, S.E. Buddu, 3800 feet, 26-30 September, 1911 (S. A. Neave), 6 ♂♂, 1 ♀ (♂ holotype); Mabira Forest, Chagwe, 3500-3800 feet, 16-25 July, 1911 (S. A. N.), 1 ♂; Buamba Forest, Semliki Valley, 2300-2800 feet, 3-7 November, 1911 (S. A. N.), 1 ♂; Mpanga Forest, Toro, 4800 feet, 13-23 November, 1911 (S. A. N.), 1 ♀ (allotype); Mulange (R. Dummer), 1 ♀ (ex coll. Joicey).

Also in coll. Jackson from Katera, February, 1936, 1 ♂ (T. H. E. Jackson).

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2. *Pseuderesia eleaza* Hew. *vidua* subsp. n.
(pl. 1, fig. 19.)

This race is to be distinguished by the longer and narrower fore-wing, the additional red basal and submarginal spots on the fore-wing above, and by the very narrow postdiscal red band on the hind-wing below, with much larger black spots in areas 3 and 4.

♀. Fore-wing narrower. *Upperside* with the red discal band wider above vein 3, and gradually curved to vein 5. Cell with two red bars, the middle one triangular, and a red basal mark. A red subapical bar formed of two spots in areas 5 and 6. Two small red submarginal spots in 3 and 4. Hind-wing with the red area extended to the base, outer edge slightly indented as in the nominotypical form, with a small red apical spot not entirely separated from the red area. *Underside* of fore-wing with increased red area and cell-marks as above. Two subapical short red bars similar to the spots above, and similarly two small submarginal spots; in the nominotypical form these four spots are much larger. Hind-wing resembles the nominotypical form except that the discal area is very pale salmon-pink instead of grey; the postdiscal black line of conjoined spots is more thinly edged with red, and where this line projects distad in areas 3 and 4, the black spots are larger. A description of the other hind-wing markings is given for the benefit of anyone who may not be acquainted with this rare species. Costa red for the proximal half. A round black spot in area 7 near the base; a similar spot in base of cell, and a much larger one beyond middle of cell; a large black spot placed outside the cell near its upper angle, anteriorly narrowed to reach vein 8, its lower edge reaching midway between veins 4 and 5; a small black spot at base of area 2, and a much larger spot below this in 1c, with a small spot in the base of 1c. A sub-basal red band formed of four large spots in the base of area 7, middle of cell, in 1c, 1a, and 1b. A large red triangular patch filling end of cell, and another more square patch in area 7 on the outer edge of the black patch. Fringes black and white, being white between the veins.

Length of fore-wing : ♀, 17 mm.; expanse : 36 mm. In the nominotypical form the fore-wing measures 15 mm., and the expanse is 32 mm.

P. nigra Cator, from Sierra Leone, is at most only a race of *eleaza*; the ♀ is scarcely different from *eleaza*. *P. variegata* Sm. & Kby., from the Cameroons, appears to be the ♀ of *eleaza*.

There is a ♀ in the British Museum from Fernando Po which shows smaller red areas, but otherwise does not seem sufficiently distinct to denote a race.

Hab.—UGANDA : Jinja, May, 1921 (*Van Someren*), 1 ♀ (type, in the Hope Dept., Oxford).

3. *Pseuderesia dinora* Kby. *discirubra* subsp. n.

This race differs in the shape of the red areas above, whilst on the hind-wing below, the greater part of the cell is red.

♀. *Upperside* of fore-wing with a wider red area above vein 3. Hind-wing without a black discocellular spot. The black border wider, reaching the costa at the apex. *Underside* of fore-wing with red area as above. The olive-green apical patch, and the marginal spots, larger, similarly on the hind-wing. Here the rounded black spots are smaller than in the nominotypical form. Cell red for the distal two-thirds, with a central rounded black spot having a grey ring. The red postdiscal spots have a narrower black proximal edging, and the distal grey waved line is much more strongly dentate.

Hab.—UGANDA : Kampala, January, 1935 (*T. H. E. Jackson*), 1 ♀ in coll. Jackson. KENYA : Yala River, south edge of Kakumga Forest, 4800–5300 feet, 21–28 May, 1911 (*S. A. Neave*), 1 ♀ (holotype).

4. *Pseuderlesia favillacea* Grünb. *griseata* subsp. n.
(pl. 1, fig. 20.)

The Uganda race of this species is to be recognised by the red patch of the fore-wing above being wider and also extended to vein 5.

♂. *Upperside* of fore-wing with wider red patch, extended distad, anteriorly the area in 3 but little shorter than the area in 2, with a small spot in 4. Hind-wing with red area reduced basally, not reaching vein 2 nor middle of cell. *Underside* of fore-wing with an additional red submarginal spot in area 3. Inner red area extended to a patch in area 2, with a small spot in 3 touching vein 4. Hind-wing very like the nominotypical form. The red cell-bar and discal bar both wider, the red spot below the cell much wider. Ground-colour more strongly speckled with white, and the two grey-white submarginal lines are more distinct than is the case in the nominotypical form.

Hab.—UGANDA: Entebbe, January, 1935 (*T. H. E. Jackson*), 2 ♂♂ (holotype; paratype in coll. Jackson; west shore of Lake Victoria, Buddu, 3700 feet, 19–25 September, 1911, 1 ♂ in poor condition (*S. A. Neave*)).

5. *Aslauga purpurascens* Holl. *marginaria* subsp. n. (? vel forma).
(pl. 1, fig. 16.)

The locality for this specimen is the most northerly known for the species. The typical form occurs at Masindi, farther south.

♂. Smaller than is usual for the species, fore-wing narrower, hind-wing with much less prominent anal lobe. *Upperside* as in the nominotypical form. *Underside* with a pattern which is more usually seen in species of Geometrid moths; the pattern is nearly achieved by some species of the genus *Tephriina*. Ground-colour browner, wings less strongly dusted with black. Both wings with a wide and prominent dark outer border; on the fore-wing this border is 3.5 mm. wide on vein 3, and on the hind-wing it is 3.75 mm. wide on vein 3, with a straight edge; on both wings it reaches to within about 1.5 mm. of the cell end; on the fore-wing its edge is not entirely straight, but is rounded below vein 3.

Length of fore-wing: 12 mm.; expanse: 26 mm. In a specimen of the nominotypical form of similar size, the width of the fore-wing between the apex and tornus is 8 mm.; in *marginaria* it is 7.5 mm.

Hab.—UGANDA: Gulu District (north-east of Lake Albert), Lamogi Camp, 1925 (*G. D. H. Carpenter*), 1 ♂ in Hope Dept., Oxford.

6. *Micropentila jacksoni* sp. n.
(pl. 1, figs. 17, ♂, 14, ♀.)

This species has white underside markings the arrangement of which points to some affinity with *mabanga* Beth.-Bkr., a species with the orange and yellow markings characteristic of this section of *Micropentila*.

♂. *Upperside* black. Fore-wing with an indistinct dusky-white postdiscal line, yet more distinct than the similar but orange line in *mabanga*; this line is thickened at the costa, in areas 2 and 3, and on the inner margin; its anterior part from costa to vein 5 is nearly at right angles to costa, and a little curved in area 5; from vein 5 to the inner margin it is parallel with the outer margin. At the end of the cell is a pale U-shaped mark, its outer edge crossing the discocellulars. Below the cell, at the point of origin of vein 2, is a small pale spot; a similar spot, but less distinct, is placed near the margin in area 5. Hind-wing with a similar postdiscal line to that on the fore-wing, but not accentuated; this line ends posteriorly at a yellowish-white patch on the margin, which reaches vein

1b and narrows along the margin to the base. *Underside* with blackish-brown ground-colour. Fore-wing with a postdiscal line as above, but more distinct, sometimes interrupted between veins 5 and 6, and posteriorly merged into the grey colouring of the submedian area, becoming indistinct below vein 2. A pale spot in the end of the cell, and only a few whitish scales on the cross-veins. The marginal spot in 5 is white and prominent. A fine white submarginal line parallel to the postdiscal line; a similar antemarginal line, both lines interrupted at the veins; the spot in 5 is placed between the two lines. Hind-wing with a prominent white discal band, similar in size and shape to the band in *mabanga* B.-B., and in *brunnea* Kby. It is 1.5 mm. wide on vein 3, with its inner edge incurved between veins 5 and 6, its outer edge excurved between veins 5 and 6, and is narrowed at both ends. A thin white interrupted submarginal line, formed of dots or lunate marks; between veins 5 and 7 this line is close to the discal band. An antemarginal white line as on the fore-wing, and similarly a white marginal spot in 5. Between the submarginal and antemarginal lines there is a blackening of the ground-colour between the veins, indicating a series of spots. Basal area powdered with dusky-grey, and a circular spot is formed at end of cell; the inner margin is similarly powdered.

♀. *Upperside* ground-colour paler than in the male. Fore-wing markings as in the ♂, but pale yellow-brown and much more conspicuous. The postdiscal band is posteriorly wider. Besides the marginal spot in 5 there are two similar but slightly smaller spots in 2 and 3. Hind-wing with pale yellow discal band which is wider than in the ♀ of *mabanga* and *brunnea*, being 2 mm. wide on vein 3; inner edge of this band fairly straight, extending from vein 6 through the cell by the point of origin of vein 2 to the inner margin where it is a little narrower; inner edge of the band slightly crenulate. There is a trace of a pale interrupted submarginal line. *Underside* markings as above, more sharply defined, and other markings as in the ♂. The anterior spot of the postdiscal band is white and the marginal spots are white. Hind-wing markings as in the ♂, white, the discal band as above; two small triangular marginal spots in 2 and 3. The grey-white basal powdering of the ♂ resolves itself in this ♀ specimen into three transverse bands, crossing end of cell, middle of cell, and base of cell. Underside of abdomen, thorax, and palpi grey. Legs blackish-brown marked with grey.

Length of fore-wing: ♂, ♀, 13 mm.; expanse: ♂, ♀, 29 mm.

Hab.—UGANDA: Katera, August, 1935 (*T. H. E. Jackson*), 1 ♂, 1 ♀ (types); west of Lake Victoria, Malabigamba Forest, Katera, October, 1935 (*T. H. E. J.*), 1 ♂ (only the wings preserved).

7. *Epitola conjuncta* Sm. & Kby. *budduana* subsp. n.
(pl. 1, figs. 2, ♂, 3, ♀.)

As no specimens of the nominotypical form were available for comparison, the specimens were compared with the figures in Smith and Kirby, *Rhop. Exot.*, 2, *African Lycaenidae*, pl. XX, figs. 3 and 4. The type is in the Berlin Museum.

♂. *Upperside* of fore-wing scarcely differs from the nominotypical form; the cell-stripe and the stripe in area 2 may be shorter. Hind-wing with blue area extended into area 6, almost reaching vein 7. The outer black border much narrower than in *conjuncta*. *Underside* of fore-wing with wider costal brown area, extending farther into the cell. Inner margin with grey border reaching the tornus. Hind-wing markings faint, not described by the authors of *conjuncta*. A curved pale postdiscal line from just beyond the middle of costa to inner margin a little above the anal angle; midway between this line and the margin is a second pale line of semi-lunate marks, also a third similar line placed near the margin.

♀. Compared with two specimens from the Cameroons, and with the figure in Smith and Kirby (pl. XX, fig. 5). *Upperside* of fore-wing with the pale lower spot (in area 4) placed a little farther distad of the one above it, and no indication of pale discal markings below this spot. A minute blue dot is to be seen in areas 1b and 2, placed nearer the margin than to the cell. Hind-wing with some sparse bluish-grey dusting over the distal area, without, however, rendering this area paler than the rest of the wing.

Hab.—UGANDA: Katera, August, 1935 (*T. H. E. Jackson*), 1 ♂, 1 ♀ (types); Tero Forest, S.E. Buddu, 3800 feet, 26–30 September, 1911 (*S. A. Neare*), 4 ♂♂; west of Lake Victoria, Malabigamba Forest, Katera, August, 1935 (*T. H. E. J.*), 1 ♂.

Mimacraea marshalli Trim.

Three races with four forms of this species are found in Kenya and Uganda. The race *dohertyi* Roths. is found on the escarpment, and to the south-west of Nairobi. A form intermediate between *dohertyi* and *marshalli* occurs with *dohertyi* in an area west of Dar-es-Salaam. The second race occurs at Kitale, perhaps the northern limit for the species. The third race occurs in Kavirondo and Ankole.

Genitalia.—The parts are strongly sclerotised. Falces long and not much curved. Clasper lobed at apex; the ventral lobe is long and narrows to a point; dorsal lobe shorter and rounded, the margin between the lobes more or less incurved. The ventral margin of clasper partly membranous.

The nominotypical form has the ventral lobe toothed, a character which distinguishes it from other races. In the race from Kitale, the dorsal lobe is rather smaller, and in the Kavirondo race the lobes resemble those of the nominotypical form except for the tooth. In *dohertyi* there is only slight differentiation from the Kavirondo race.

8. *Mimacraea marshalli dohertyi somereni* form. n.
(pl. 1, fig. 10.)

A striking form which only differs from *dohertyi* in having a broad white subapical band on the fore-wing. There is a variable amount of apical black, and the white band ranges from being 3.5 mm. wide in area 5 to a little narrower width.

Hab.—KENYA: South-west Nairobi and eastwards. Ngong, Escarpment, 7 October, 1924, 1 ♀ (holotype); Kiborani, 4500 feet, 12 January, 1918, 200 miles west of Dar-es-Salaam, 1 ♂ (allotype), in the Hope Dept., Oxford; Mbagathi, west-south-west of Nairobi, 6000 feet, October, 1929, 1 ♂ (*K. St. A. Rogers*), in the Hope Dept., Oxford.

The two latter specimens show more apical black on the fore-wing, and a little narrower white band. The underside is also more laved with white. Specimens of the *dohertyi* form were also collected at Mbagathi.

9. *Mimacraea marshalli media* subsp. n.
(pl. 1, fig. 11.)

A smaller race with the *chrysippus* pattern.

♂, ♀. *Upperside* of the fore-wing with the white subapical band narrower, and the spot in area 4 noticeably smaller, than in the nominotypical form. Hind-wing with narrower black marginal border. *Underside* of fore-wing with a longer stripe in area 3, the black colour between this and the marginal spots reduced. In area 2 no submarginal black

scaling indicating the separation of a marginal spot as is usual in the nominotypical form. The hind-wing does not appear to differ from the Rhodesian race.

Length of fore-wing: ♂, 22–24 mm.; in *marshalli marshalli*: 26–28 mm.

Genitalia.—The clasper more resembles *dohertyi* than other races, but is not so broad in its apical part.

Hab.—KENYA and UGANDA: South Kavirondo, west boundary, Mirua or Sondo River Valley, 4500 feet, 14 May, 1911 (S. A. Neave), 2 ♂♂ (holotype); *id.*, 2 May, 1911, 1 ♂; South Kavirondo, Migori Valley, 4200 feet, 24 May, 1911 (S. A. N.), 1 ♀; North Kavirondo, Bussey, October, 1923 (T. H. E. Jackson), 1 ♂; Nyanza Province (Ainsworth), 1 ♂; Uganda, South-east Ankole, 4400–4800 feet, 4–8 October, 1911 (S. A. N.), 1 ♂, 2 ♀♀ (♀ allotype).

In the Hope Dept., Oxford, from South Kavirondo, Kisi District, 5000 feet, March, 1911 (S. A. N.), 3 specimens; Uganda, Mbarara, December, 1920 (G. D. H. Carpenter), one specimen.

The holotype and the Jackson specimen were dissected.

10. *Mimaeraea marshalli nzoia* subsp. n.

(pl. 1, fig. 12.)

A small race from the Kitale district, resembling *media*.

♂. *Upperside* of fore-wing with a wider subapical band than in *media*, the posterior spot much larger. *Underside* of fore-wing as in *media*. Hind-wing with the black spots more strongly edged with grey than in *media*; the two costal spots closer together, the outer one being placed nearer the end of the cell. A heavy black bar across the discocellulars. Veins strongly edged with grey-white.

Length of fore-wing: 23 mm.

Genitalia.—Still more distinct from *dohertyi* than is *media*. The rounded lobe of the clasper is much smaller, the margin between the lobes is not strongly incurved, and the width below the lobes is greater than in *media*.

Hab.—KENYA: Kitale, July and August, 1932 (Van Someren), 1 ♂.

11. *Liptena eukrinoides* sp. n.

(pl. 1, fig. 18.)

Belongs to the group of *eukrines* Druce, with ochre-yellow colouring, and apparently nearest to *eukrinaria* B.-Bkr. Distinguished from allied forms by the pattern of the hind-wing below.

♂. *Upperside* resembles *eukrinaria* from the Cameroons. Fore-wing black apical area with a fairly straight edge, not indented as in the allied forms. Costal margin black, a little wider beyond the cell, and narrowly separated from the apical area. The posterior linear prolongation of the apical black only exists as a thin short line which joins the black fringe just below vein 3. Hind-wing unmarked. *Underside* with all markings indistinct. Fore-wing paler ochreous than above, with these markings reproduced in brownish-ochreous. A dark brown submarginal line ending in a point below vein 3. Hind-wing pale ochreous-brown with darker markings. A discocellular mark; an indistinct cell-spot; a narrow curved postdiscal band from costa to inner margin, its edges not sharp, the inner one fairly even, and the outer one irregular; a similar postdiscal band, widening in areas 3 and 5, its outer edge somewhat crenulate. A dark marginal border bearing a pale line of sublunate bars. Fringe of fore-wing above with the inner half black, the outer half paler; below with the outer half mixed with white. Hind-wing above with the fringe blackish-brown tipped with white, except in the apical area, where it is yellow; underside pale brown with a blackish-brown line marking the inner edge. Frons blackish-brown with narrow

white edging at the sides. Palpi with first segment white, second segment white except for the apical fifth which is black above and at the sides, third segment black. Legs dark ochreous mixed with black.

♂. *Upperside* markings as in the ♂, but the specimen is somewhat worn, though in good condition on the underside. *Underside* paler than in the ♂, especially so are the brown areas which on the hind-wing show better defined markings. There is a sub-basal band crossing the cell before vein 2; a discal band, which only runs from lower angle of cell to inner area; a postdiscal band, just beyond cell as in ♂; a postdiscal line placed near the submarginal area as in the ♂. The pale submarginal line is wider than in the ♂, and is continuous and more regular.

Length of fore-wing: ♂, 14 mm., ♀, 16.5 mm.; expanse: ♂, 30 mm., ♀, 34 mm.

Hab.—UGANDA: Tero Forest, South-east Buddu, 3500 feet, 26–30 September, 1911 (*S. A. Neare*), 1 ♂ (holotype); Katera, December, 1935 (*T. H. E. Jackson*) (♀ allotype, in coll. Jackson).

LYCAENINAE.

12. *Epamera neavei katera* subsp. n.

(pl. 1, fig. 13.)

♂. *Upperside* differs but slightly from the nominotypical form from the Cameroons. Fore-wing with blue area entering base of area 2. Hind-wing with black apical border a little wider, and may extend farther posteriorly, but the wings are a bit worn and one cannot be sure. *Underside* of fore-wing with wider dark grey marginal shade; postdiscal line a little farther from the margin. The silvery speculum below the cell is not extended so far towards the tornus as in the nominotypical form. Hind-wing with the postdiscal line farther from the margin. The black submarginal spot in area 2 much smaller, the anal spot of a similar size; the orange edging of these spots much reduced, and the orange line obsolete. Head with vertex and frons orange, the latter with slight white admixture.

Hab.—UGANDA: Katera, November, 1933 (*T. H. E. Jackson*). 1 ♂. The specimen has lost the anal area of both wings.

13. *Epamera iusis albomaculatus* Sharpe, ♀.

(pl. 1, fig. 7.)

♀. Differs from the nominotypical form as follows:—*Upperside* of fore-wing with blue area more extended between vein 4 and inner margin; in areas 2 and 3 bearing some white scales. Hind-wing with blue area not reaching vein 6, the blackish costal area reaching to the cell and to below vein 6. *Underside* more resembles the *albomaculatus* ♂ than it does the ♀ of the nominotypical form. There is a thin postdiscal line on both wings; on the fore-wing it is formed of five curved marks in areas 1b, 2, 3, 4, 5, the two lower ones a little nearer the margin than the others; apical area to vein 4 lightly washed with smoky-brown. The hind-wing postdiscal line is continuous from vein 7 to 1a, nearly straight from vein 7 to vein 4, but in areas 3, 2, 1c, and 1b it is crenulate, being very strongly curved in 1c. A brick-red submarginal spot in 2, with a black dot on its outer edge; a black anal spot with a larger brick-red spot on its inner side as in the ♂.

Hab.—UGANDA: Katera, January, 1936 (*T. H. E. Jackson*) (1 ♀, neallotype).

14. *Lepidochrysops grandis* sp. n.

(pl. 1, figs. 9, ♂, 8, ♀.)

Allied to *leucon* Mab.

♂. Larger than *leucon*, of a brighter and more lustrous blue. *Upperside* of fore-wing with a more prominent black discocellular streak, and a broader black apical and marginal

border, somewhat as in *azureus* Butl. Hind-wing costal border blackish-brown, extended narrowly in area 6 as a marginal bar to vein 6, separated from the black marginal line by a thin grey-white line. A small black anal spot in area 2, and a larger and somewhat diffuse black anal spot in 1c. *Underside* markings resembling *leucon*. Fore-wing with a black submarginal border, 1.5 mm. wide in area 4, wider at the apex, formed of coalescent spots, and therefore slightly indented at the veins; it narrows from apex to costa, and slightly so posteriorly to vein 1a. A thin white crenulate antemarginal line, and a thin black marginal line. An indication of a second submarginal line of black marks, but the only distinct ones are in areas 1b and 2. A black discal spot as in *leucon*. A postdiscal series of 5 black spots; the lower spot larger than in *leucon*, and the one in 4 is longer. Hind-wing markings as in *leucon*, but the postdiscal spots are all much larger, so are the submarginal spots which are more triangular. Fringe of fore-wing black, of hind-wing white, interrupted by black at the veins.

♀. Relatively larger than *leucon*, with wider black border on fore-wing above. Fore-wing white with black outer border from costa to vein 1a; this border is 5 mm. wide in area 4, and 4 mm. below vein 2, becoming wider over the apical area, narrowing to the black costal border; only a small basal part in areas 6-8 remains white. A black discocellular mark as in *leucon*. Hind-wing as in *leucon*, the black costal area reaching vein 6, leaving a small white or dusky submarginal spot in area 6. The small submarginal spots in areas 3-5 are larger than in *leucon*. A rounded black submarginal spot in 2, dotted with dark blue scales (in *leucon* with 3 or 4 blue scales or none). A submarginal black bar, partly dusted with bluish-grey in 1c; proximally of these are two anal spots, and in each area is an indistinct blackish bar. A black marginal line as in *leucon*. *Underside* as in the ♂. Fringe of fore-wing black, of hind-wing white, interrupted by black at the veins.

Length of fore-wing: ♂, ♀, 24 mm.; expanse: ♂, ♀, 52 mm.

Hab.—MADAGASCAR: Tananarivo (*Lamberton*), 1 ♂ (ex coll. Oberthür) (holotype). Also 2 ♀♀ January 1916 (G. K. Kestell-Cornish). The allotype ♀ in British Museum, the paratype in the Hope Dept., Oxford.

15. *Lepidochrysops leucon* Mab., ♂.
(pl. I, fig. 4.)

♀. *Lycaena leucon* Mabille, 1879, *Pet. Nouv. ent.*, 2 (211): 289; 1887, in Grandidier, *Hist. nat. Madag.*, *Lep.* : 226, figs. 6, 6a.

The male described and figured by Mabille (*loc. cit.*, figs. 5, 5a) is *azureus* Butl., which is a distinct species. Bethune-Baker, in his revision of the group (1923, *Trans. ent. Soc. Lond.*, 1923) was of the same opinion as Mabille, and he was followed by Aurivillius in 1925 (*Seitz' Macrolep.* 13). Owing to the confusion over the two species, the ♂ of *leucon*, as well as the ♀ of *azureus*, appears to be still undescribed.

Upperside darker blue than in *azureus*. Fore-wing without a dark border, only a heavy black marginal line which is thicker at the apex. Discocellular mark much less prominent than in *azureus*. Hind-wing resembles *azureus*, but there are no submarginal spots, or only traces of them, in areas 3-5; a smaller black anal spot in 2 which may be absent. *Underside* resembles the ♀. Some specimens differ from the type figured by Mabille in having heavier postdiscal spots, with the spot in area 4 forming an obliquely placed bar, its distal end being nearer the margin than are the other spots. Fringe of fore-wing black, of the hind-wing white, interrupted by black at the veins.

Length of fore-wing: ♂, 18-21 mm., ♀, 25.5 mm.; expanse: ♂, 42-44 mm.; ♀, 52 mm.

Genitalia.—There is a distinct difference in the form of the clasper between *leucon* and *azureus*. In *azureus* it is evenly curved and of fairly even width

from the base of the hook to where the clasper expands at the base (cf. Bethune-Baker, 1923, pl. XVI, fig. 1). In *leucon* the clasper bulges at the base of the hook, so that a rounded projection is formed on the dorsal edge; opposite this on the ventral side there is also a slight protuberance. The hook appears to be a little longer and sharper.

Hab.—MADAGASCAR. Neallotype ♂ in the British Museum ex coll. Oberthür, labelled “Madagascar, H. Perrot.” Also 4 other males from Tamatave: 2 ex coll. H. H. Druce, 2 ex coll. Brabant, and all from the Paris dealer, the late Donckier de Donceel. Also in the British Museum the ♀ holotype, ex coll. Grose-Smith, together with the ♀, ex coll. Mabille, referred to in his *Hist. nat. Madag., Lep.*

16. *Lepidochrysops azureus* Butl., ♀.

♂. Butler 1879, *Ann. Mag. nat. Hist.* (5) 4 : 230.—Bethune-Baker 1923, *Trans. ent. Soc. Lond.*, 1923, pl. XV, figs. 1, 1a (genit.).

Closely resembles *leucon* Mab., but differs from this and agrees with its ♂ in having a prominent row of submarginal black marks on both wings below.

Upperside of fore-wing with marginal dark border wider than in *leucon*, and extended to the inner margin. Hind-wing costal dark area not reaching vein 6 distally, there being at least a small white or dusky apical patch. A faint submarginal crenulate line, absent in *leucon*. The black anal spot in area 2 is proximally edged with ochreous. *Underside* as in the ♂, the rounded submarginal spots larger on the hind-wing.

Length of fore-wing : 20–21 mm.; expanse : 43–46 mm.

Hab.—MADAGASCAR: Fianarantsoa, 2nd semestre, 1892 (*Perrot Frères*) (ex coll. Oberthür), ♀ neallotype; Beforona, East Central Madagascar, 2 ♀♀ (ex coll. Joicey); Antananarivo (*Kingdom*) (ex coll. Oberthür), 1 ♀. Also 1 ♀ without precise locality, and a number of males.

17. *Anthene wilsoni* Talb., ♂.
(pl. 1, fig. 6.)

♀. *Lycaenesthes (Cupidesthes) wilsoni* Talbot 1935, *Ent. mon. Mag.*, 71 : 121, pl. II, fig. 10, pl. III, fig. 13 (S.W. Abyssinia).

A pair of this species was taken at Kitale in Kenya by Dr. Van Someren, and a ♂ was taken by Mr. Jackson on Mt. Elgon.

♂. *Upperside* of fore-wing with blue basal area having a straight and sharply defined edge; it extends to the cell end and slightly into area 2, and at vein 1a is 3–4 mm. from the margin. Hind-wing blue for the greater part, with the costa more or less blue, this colour not quite reaching the margin. There is a small dark brown or black submarginal spot in 1c and 2. In the Kitale ♂ the blue is paler. *Underside* resembles the ♀, the ground-colour much darker. The two specimens differ slightly, but the Elgon ♂ more nearly resembles the holotype ♀. On the fore-wing the posterior spot of the band is placed less proximal; in the Kitale specimen the band is wider, and the posterior spot larger than in the holotype. Hind-wing as in the ♀ excepting for the darker ground-colour. In the Kitale specimen the band is wider and the ground-colour still darker.

The ♀ from Kitale differs slightly from the ♂. Fore-wing above with the blue area extended a little beyond the cell without any white scaling. Hind-wing not distally paler, and the blue area, as in the ♂, is sharply defined by vein 6. Underside with slightly wider bands, the submarginal line on the fore-wing thinner and broken up into lunate marks.

Length of fore-wing : ♂, 17 mm., ♀, 18.5 mm.; expanse : ♂, 36 mm., ♀, 40 mm.

Hab.—KENYA: Mount Elgon, south-east slopes, 18 km. south-west of Kitale, 6000–7000 feet, January, 1933 (*T. H. E. Jackson*), 1 ♂ (neallotype); Kitale, January, 1933 (*Van Someren*), 1 ♂, bred; Kitale, December, 1932 (*Van Someren*), 1 ♀, bred.

18. *Anthene hodsoni usamba* subsp. n.

(pl. 1, figs. 1, ♂, 5, ♀.)

Lycaenesthes hodsoni Talbot 1935, *Ent. mon. Mag.*, 71: 125, pl. II, fig. 12, pl. III, fig. 14, ♂ (S.W. Abyssinia).

This race is distinguished in the ♂ by the more pointed fore-wing, and by the darker underside, especially of the hind-wing.

♂. Fore-wing shaped as in *wilsoni* Talb., and darker blue above, without the coppery tinge of the nominotypical form. There is a darker somewhat brown marginal border from the base of costa to tornus, with a darker small submarginal tornal spot. Hind-wing coloured as the fore-wing, with brown costal area to vein 6, extending as a narrow marginal border to the anal angle, with the blue area produced at the veins. A small dark spot close to the margin in area 3; a larger and more distinct black rounded spot in 2; a brown anal bar with wide proximal yellow-brown border; a fine white marginal line, interrupted by the veins, from the spot in 3 to vein 1c. *Underside* ground-colour very dark grey. Fore-wing grey-white over the inner area to vein 2. Hind-wing with the black basal spots much smaller than in the nominotypical form.

♀. Wings more rounded than in the ♂, but slightly less rounded than in the ♂ of the nominotypical form. *Upperside* paler than in the ♂. Fore-wing with whitish discal area, and a dark and more distinct discocellular mark which, as in the ♂, only covers the upper discocellular between veins 5 and 6. Both wings with some basal metallic blue. Hind-wing with a series of whitish submarginal marks which accentuate a small dark spot in areas 2–5; small white-edged marginal spots in 1c–4. *Underside* much paler than in the ♂. Fore-wing almost as in the nominotypical form. Hind-wing markings as in the ♂, but the distal two-thirds as pale as the costal area of fore-wing.

Length of fore-wing: ♂, ♀, 15–17 mm.; expanse: ♂, ♀, 34–38 mm.

Hab.—KENYA: Eastern Rift Valley, Ngong, September, 1935 (*Van Someren*), ♂ holotype; *id.*, April, 1935 (*Van Someren*), 1 ♂, 1 ♀; Nairobi, 16 August, 1920 (*T. H. E. Jackson*), 1 ♀ (allotype).

The second male mentioned is somewhat rubbed, and the upperside is more coppery; the fore-wing is without the dark border.

19. *Anthene katera* sp. n.

(pl. 1, fig. 15.)

Allied to *lusones* Hew., which ranges from West Africa to Uganda. Distinguished from this by the very large yellow patch on the fore-wing above, and by the heavy white submarginal band on both wings below.

♂. *Upperside* of fore-wing with a rounded yellow patch occupying the greater part of the posterior area of wing; its lower edge is on the inner margin, its inner edge crosses the cell at vein 2, its upper edge does not reach the upper margin of cell, its outer edge from vein 4 slightly indented in area 3 and at veins 2 and 1a. Hind-wing as in *lusones* with a similar black orange-bordered marginal spot in area 2. *Underside* markings somewhat as in *lusones*, consisting of black spots and bands sharply edged with white. Fore-wing with smaller yellow area than above, not entering the cell and limited by vein 3. An oblique sub-basal and discal line as in *lusones*; the latter, which crosses the cell at vein 2,

much heavier than in that species, and anteriorly is farther away from the sub-basal line and closer to the white line in the cell. The submarginal white line, the lower part of which edges the yellow area, is much heavier than in *lusones*, and forms a narrow band; the two antemarginal lines are likewise more prominent. Hind-wing with wider bands which have heavier white edging. The sub-basal band is about 2 mm. wide, is more oblique, and has more even edges than in *lusones*. The black discal band, formed of two square anterior spots and a posterior V-spot, likewise much larger than in *lusones*. Submarginal line forming a narrow band which follows the same course as in *lusones*, and is accentuated at the apex by a short white bar which reaches vein 6; in *lusones* this bar is represented by two curved marks.

Length of fore-wing: 12 mm.; expanse: 26 mm.

Hab.—UGANDA: Katera, November, 1935 (T. H. E. Jackson), 1 ♂.

An equally large ♂ of *lusones*, in the British Museum from the Congo, has a yellow fore-wing patch of little above normal size. Although the bands on the underside are as wide as in the form here described, there is not the same thickening of the white lines.

NYMPHALIDAE.

20. *Diestogyna jacksoni* sp. n. (pl. 2, figs. 1, 2.)

Allied to *feronia* Stgr., also in some respects to an unnamed species in the British Museum from the Cameroons, and in its underside pattern to *simplex* Stgr.

♂. *Upperside* deep blue, but not so bright as in *feronia*, the median area of fore-wing and the hind-wing purplish. Fore-wing cell-marks as usual in the genus; the dark oval spots are edged at the sides with violet blue in the type, with purple in the Uganda specimen, showing as four violet-blue bars, the basal one indistinct, the outer one strongly marked over the cross-veins. A similarly coloured and heavier post-cellular line, slightly curved from costa to vein 2, but indistinct below vein 3; in the Uganda specimen this line is altogether less distinct. Four white subapical dots as in *feronia*, with a violet-blue dot in area 3 placed below the one in 4, a similar but larger and more obscure dot in area 2 placed a little distad of the one in 3, and a similar but small dot below vein 2 placed in line with the one in area 3. This line of dots is absent in the Uganda specimen, though there are indistinct traces of it. A submarginal series of semi-crescentic black spots similar to those in *feronia* but a little larger. Between these spots and the postdiscal line of dots, there is a row of somewhat square-shaped black spots each with an indistinct outer violet edging, not apparent in the Uganda specimen. *Hind-wing* with costal area fuscous-brown to vein 6; in *feronia* this extends to vein 4. A thin black very slightly curved discal line from vein 2 to vein 6, crossing area 2 near its base. A heavy black waved submarginal line from vein 2 to vein 6, less marked and more even in the Uganda specimen. Between the discal and submarginal lines are two indistinct blackish postdiscal bands of spots, the inner one broader than the outer; in the Uganda specimen only the outer band is distinct, and the spots forming it are short bars. The outer marginal border is fuscous-brown and less suffused with purple. *Underside* rufous-brown, resembling *simplex* Stgr. in colour and markings, and not *feronia*; the type specimen more ochreous. Fore-wing cell-marks as in allied species. Postdiscal line with the part below vein 4 nearly even and straight, directed more distad than in *simplex* or *feronia*; it is bordered outwardly with paler brown, somewhat as in *simplex*. A postdiscal row of white dots, representing the line on the upperside, much less distinct in the Uganda specimen. Midway between these dots and the margin is a deep brown submarginal line marked with

ochreous along its inner edge. In the space between the two lines mentioned there are grey-black patches in 1b, 2, and 3. *Hind-wing* basal area only a little darker than the distal area. Cell-spot not blackened. Discal line more curved than in *simplex*, and passing farther from the point of origin of veins 3 and 4 than it does in that species; this line is narrowly edged outwardly with white. A postdiscal row of white dots, and a submarginal line as in other species.

♀. Not resembling *simplex* or *feronia* but strongly suggestive of *amaranta* Ksch. or *atrovirens* Mab. ♀. *Upperside*.—Fore-wing with the rufous-brown area extending beyond the cell and into the base of area 3, with its edge sharply defined. A band of 5 white spots as in other species, but not compact as in *simplex* or *feronia*; the three anterior spots are separated by the veins and wider than in *amaranta*; the third spot in 4 has a characteristic proximal projection in the upper part of the cellule, and there is a similar projection to the large and somewhat rounded spot in 2, whilst a more obvious projection is seen on the lower and smaller curved spot. Four white subapical dots as in allied species. *Hind-wing* differing essentially from similar females of other species in its blackish-brown marginal border which almost touches the black and slightly waved submarginal line. Discal black line thin and sharply defined. A thin black divided postdiscal streak in each of areas 2–5. *Underside* coloration and hind-wing markings as in the male. Fore-wing with ground-colour as the hind-wing, paler below the cell, and with a diffuse blackish patch in areas 2 and 3 over the area in which are placed the two white spots. *Hind-wing* a little paler than in the male. Discal line indistinctly edged with white, and the tooth on vein 2 larger.

Fringes in both sexes black, in the ♂ with a white dot at apex of fore-wing.

Length of fore-wing: ♂, 30 mm. (type), 29 mm. (Uganda specimen); ♀, 35 mm.

Expanse: ♂, 64 mm. (type), 60 mm. (Uganda specimen); ♀, 75 mm.

Hab.—EASTERN CONGO: Upper Lowa Valley, near Masisi, West Kivu, 5000–6000 feet, February, 1921, wet season, in forest and long grass country, 1 ♂ (*T. A. Barns*) (ex coll. Joicey) (holotype). UGANDA: Katera, November, 1935, 1 ♂ (*T. H. E. Jackson*); *id.*, November, 1933, 1 ♀ (*T. H. E. Jackson*) (♀ allotype). The Uganda specimens are in coll. Jackson; the holotype is in the British Museum.

The species may be distinguished by the rounded wings, by the hind-wing not produced posteriorly, by the deep bluish or purplish tone of the upperside, and by the reddish-brown underside which is free from grey or dark suffusion.

21. *Diestogyna chalybeata* sp. n.

(pl. 2, figs. 3, 4, ♂, 5, 6, ♀.)

The upperside coloration resembles *simplex* Stgr. or *saphirina* Karsch. Underside markings somewhat as in *obsoleta* Grünb., especially the hind-wings. The vestiture on the inner area of hind-wing is posteriorly developed to form a tuft.

♂. *Upperside* dark leaden blue with a greenish tinge on the fore-wing; markings indistinct. Fore-wing with the usual cell-marks. The postdiscal line is only visible as far as vein 2, and from vein 5 to vein 2 is almost straight or at right angles to the inner margin. The submarginal band of dark spots is narrower than in *obsoleta*, and wider than in *saphirina*. As in the latter species there are no subapical white dots, and the apex and outer border are blackish for about 3 mm., narrowing to the tornus below vein 2. *Hind-wing* with pale smoky-brown costal area as in *obsoleta*, and reaching vein 4 as in that species; similarly the anterior part of the two submarginal lines of blackish spots is distinct on the pale apical area, though less defined than in *obsoleta*. The fringe of blackish hair

along vein 1b is strongly developed, but stops at about 7 mm. from the margin and forms a pronounced tuft which reaches to within 5 mm. of the margin; the hair forming this tuft arises chiefly from the fold in 1c, and no hair arises above the fold as is the case in the two allied species where it covers most of the area. *Underside* chestnut-brown strongly irrorated or freckled with smoky-brown. Basal area dark smoky-brown with indistinct cell-marks. Discal line as in *obsoleta*, of the same curvature and outline. Distal apical and costal area to vein 4 dusted with bluish-white. Posterior area pale smoky-brown. The two dark submarginal bands as on the upperside and not distinct; proximally of the inner band are four bluish-white dots in areas 4, 5, 6, and 8. Hind-wing ground-colour deep chestnut with darker basal area. A rounded and conspicuous pale buff spot near the base of area 7, and a similar but somewhat square or oblong spot in 1c on the edge of the dark basal area; similar pale spots, though less defined, are found in *obsoleta*. The basal area is bordered diffusely with deep chestnut, and there is a postdiscal band of similar colour, broken up into spots, each spot with an indistinct white dot upon its proximal edge. The distal area irrorated with smoky-brown, and bearing an indistinct blackish waved submarginal line. Fringe of fore-wing white, blackish at the veins; of the hind-wing black. Abdomen with grey ventral surface; in *obsoleta* it is ochraceous.

♀. Resembles somewhat *atropurpurea* Auriv. on upperside, and *amaranta* Ksch. on underside. *Upperside* of fore-wing dull ochreous in basal area as in *atropurpurea*, with the three dark cell-patches sharply outlined with ochreous; the patch across the end of cell is larger than in the two species mentioned. The pale patch lying between vein 2 and inner margin is large in the type and in specimen 2, in specimen 3 it is as in *atropurpurea*, and in specimen 4 it is represented by a curved buff-coloured mark in 1b. The dark angled line edging the inner side of this patch is much the same as in *atropurpurea*. It may be mentioned here that this submedian patch is absent in *amaranta*. The white band is quite the same as in *atropurpurea*, and the usual four white subapical spots are present. Hind-wing closely resembles *atropurpurea* in markings. The discal line, which edges the dark basal area, is but slightly curved and fairly even. The postdiscal blackish patches, more distinctly developed than in *atropurpurea*, very large in specimen 4 where also the second postdiscal row of dark patches is more developed; in the other specimens these patches, as well as the submarginal sagittate line, are as in *atropurpurea*. *Underside* more as in *karschi* or *amaranta*. Fore-wing with cell-marks and whitish-dusted apical area as in the ♂. An indistinct ochreous submarginal band about 3 mm. wide from costa to vein 4, the white dots, as above, on its inner edge. The pale submedian patch reproduced but less distinct than above. Hind-wing basal area blackish-brown irrorated with pale buff to a variable extent. The irregularities along the edge of the basal area, including the tooth on vein 2, are just as in the ♂. There is a pale ochreous spot near the base of area 7 as in the ♂, and from this, to the margin near the base, is a curved blackish band, constricted slightly in the cell, and including the dark rounded cell-spot. Distal area pale ochreous, more or less strongly freckled with chestnut. The postdiscal blackish spots as on upperside; indistinct in the type and in specimen 2, but very distinct in the other two examples; in allied forms these spots are either small triangles or mere dots. A waved dark submarginal line as in *karschi* but still heavier; the space between this line and the margin more or less irrorated with blackish. Fringe of both wings black.

Length of fore-wing: ♂, 27–30 mm., ♀, 32–33 mm.; expanse: ♂, 58–62 mm., ♀, 66–77 mm.

Hab.—EASTERN CONGO: Upper Lowa Valley, west of Masisi, West Kivu, 4500–5000 feet, September, 1921, 1 ♂ (*T. A. Barnes*) (ex coll. Joicey) (holotype). UGANDA: Katera, November, 1933, 2 ♂♂, 1 ♀ (*T. H. E. Jackson*); *id.*, October, 1932, 1 ♀ (allotype); *id.*, August, 1935, 1 ♀; *id.*, November, 1935, 1 ♀. The types in British Museum, and others in coll. Jackson.

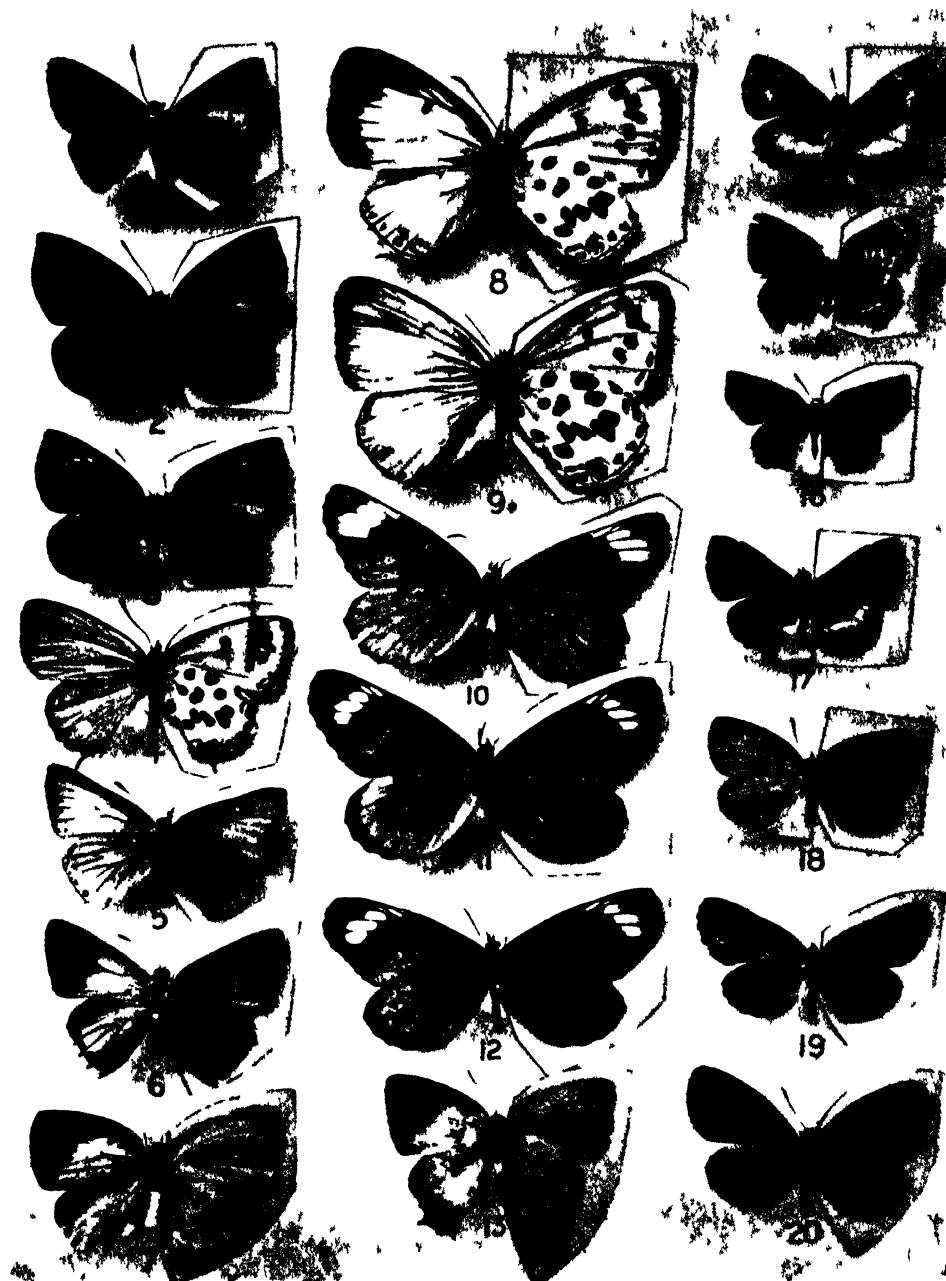
EXPLANATION OF PLATE 1.

(The right-hand pair of wings shows the undersides.)

FIG. 1. *Anthene hodsoni usamba* subsp. n., ♂ holotype.
 2. *Epitola conjuncta budduana* subsp. n., ♂ holotype.
 3. *Epitola conjuncta budduana* subsp. n., ♀ allotype.
 4. *Lepidochrysops leucon* Mab., ♂ neallotype.
 5. *Anthene hodsoni usamba* subsp. n., ♀ allotype.
 6. *Anthene wilsoni* Talb., ♂ neallotype.
 7. *Epamera iasis albomaculatus* Shpe., ♀ neallotype.
 8. *Lepidochrysops grandis* sp. n., ♀ allotype.
 9. *Lepidochrysops grandis* sp. n., ♂ holotype.
 10. *Mimacraea marshalli dohertyi* f. *somereni* form n., ♀ holotype.
 11. *Mimacraea marshalli media* subsp. n., ♂ holotype.
 12. *Mimacraea marshalli nzoia* subsp. n., ♂ holotype.
 13. *Epamera neavei katera* subsp. n., ♂ holotype.
 14. *Micropentila jacksoni* sp. n., ♀ allotype.
 15. *Anthene katera* sp. n., ♂ holotype.
 16. *Aslauga purpurascens marginaria* subsp. n., ♂ holotype.
 17. *Micropentila jacksoni* sp. n., ♂ holotype.
 18. *Liptena eukrinoides* sp. n., ♂ holotype.
 19. *Pseuderesia eleaza ridua* subsp. n., ♀ holotype.
 20. *Pseuderesia favillacea griseata* subsp. n., ♂ holotype

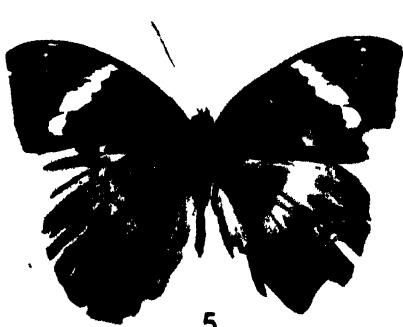
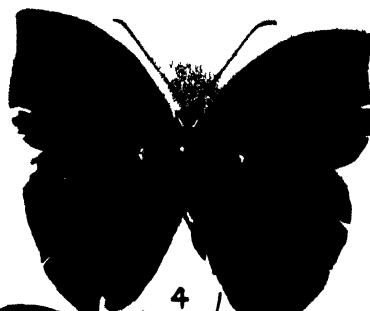
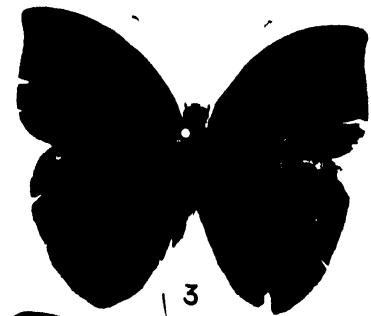
EXPLANATION OF PLATE 2.

FIG. 1. *Diestogyna jacksoni* sp. n., ♂ holotype.
 2. Underside of fig. 1.
 3. *Diestogyna chalybeata* sp. n., ♂ holotype.
 4. Underside of fig. 3.
 5. *Diestogyna chalybeata* sp. n., ♀ allotype.
 6. Underside of fig. 5.



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New African Lycaenids.



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New African Nymphalids.

ON THE PRE-ADULT INSTARS OF *PSEUDOCOCCUS LONGISPINUS*
TARG., WITH SPECIAL REFERENCE TO CHARACTERS OF
POSSIBLE GENERIC SIGNIFICANCE (HEM.)

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[Read 18th November, 1936.]

WITH SIX TEXT-FIGURES.

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INTRODUCTORY.

THIS paper has been written as the result of a study of the immature stages of *P. longispinus* and their comparison with numerous larvae of other species of *Pseudococcus* (*sens. str.*). Comparative studies indicate that three larval instars in the female and four in the male are usual and should perhaps be regarded as invariable for the genus *Pseudococcus*. Berlese (2) is the only entomologist who has treated the pre-adult instars of *Pseudococcus* from the morphological standpoint, and he found that there are three larval instars in the female of *P. citri* Risso and *P. longispinus* and one larval and two pupal stages in the male. It is now apparent, however, that one instar was overlooked in the male, owing to the defective staining methods then in vogue (1893) failing to disclose the fact that sexual dimorphism is recognisable in the second instar as will be hereinafter described.

Since the work of Berlese a number of biological studies of species of *Pseudococcus* have been made, and Hough (3) in *P. comstocki*; Kirkpatrick (7) in *P. lilacinus* (now re-described as *P. kenyae* Le Pelley); Myers (8) in *P. citri*; and Basinger (1) in *P. gahani* discovered three larval instars in the female and four in the male of the species with which they were concerned. However, critical morphological examination of the larval stages does not appear to have

been made, and this is almost imperative in the early instars if full assurance is desired that all stages have been observed.

As I had on hand a series of mounts of all the stages of a number of species I decided to describe the pre-adult instars of *longispinus*, the genotype of *Pseudococcus*, and by a comparative study with the corresponding stages of other species to recognise characters which I considered to be uniformly distinctive of each instar.

If the work of Uitchanco (9) on the life-history of *Trionymus sacchari* is confirmed, it suggests that studies of the pre-adult instars of species of *Pseudococcus* and of allied genera will be of assistance in the delimitation of a number of nebulous generic boundaries in this group.

I wish again to express my indebtedness to Dr. A. D. Imms, F.R.S., for facilities and useful suggestions.

(1) Oviposition and oviparity in *P. longispinus*.

The egg of *longispinus* is an ovoid pale yellow object about 0.25 mm. long, and at the time of oviposition the contained embryo is fully formed. The process of hatching begins about fifteen minutes after oviposition, and thus although the duration of external incubation is very short *longispinus* is technically speaking oviparous.

If a number of ovipositing females are placed in glass tubes so that the ventral surface of the abdomen can be kept under observation an egg will soon be detected in the act of being expelled through the genital pore. Almost immediately after oviposition movements of the egg brought about by the full-grown embryo can sometimes be seen, and microscopic observation will then reveal that the chorion is closely appressed to the contained embryo and that the outlines of the latter are apparent.

The rupture of the chorion takes place ventrally between the prothoracic legs, and is effected by vigorous movements of the rostrum after the egg membrane has been drawn taut by the flexure of the body. The prothoracic limbs are freed first and are soon followed by the antennae and the mesothoracic limbs; the liberation of the hind limbs are effected mainly by vigorous movements of the abdomen, and the exuvia is gradually worked back to the hind end of the body, where it dries and is subsequently rubbed off.

Hatching in *longispinus* was watched with more than usual interest, owing to the allegation (9) that the act of eclosion occurs *in utero* in a species of mealybug (*Trionymus sacchari*) whose ova appear to have a period of external incubation comparable with that of *longispinus*. It is held that what issues from the genital pore of *T. sacchari* are not ova but forms comparable with the vermiform larvae of Uvarov (10), and that what has hitherto been mistaken for the act of eclosion is really the first post-embryonic moult.

Hence the matter has importance in the fixation of the number of instars in *longispinus*, and it was observed in the case of the latter species that the first pellicle cast after expulsion from the vagina is a simple capsule without separate investing sheaths for the antennae and limbs which would necessarily form part of the exuvia of the first post-embryonic ecdysis.

(2) The Pre-adult instars of *P. longispinus*.

(a) *The first instar.*

The first instar at eclosion is of the same colour as the egg, and varies in length from about 0.25 mm. at hatching to about 0.60 mm. in length and

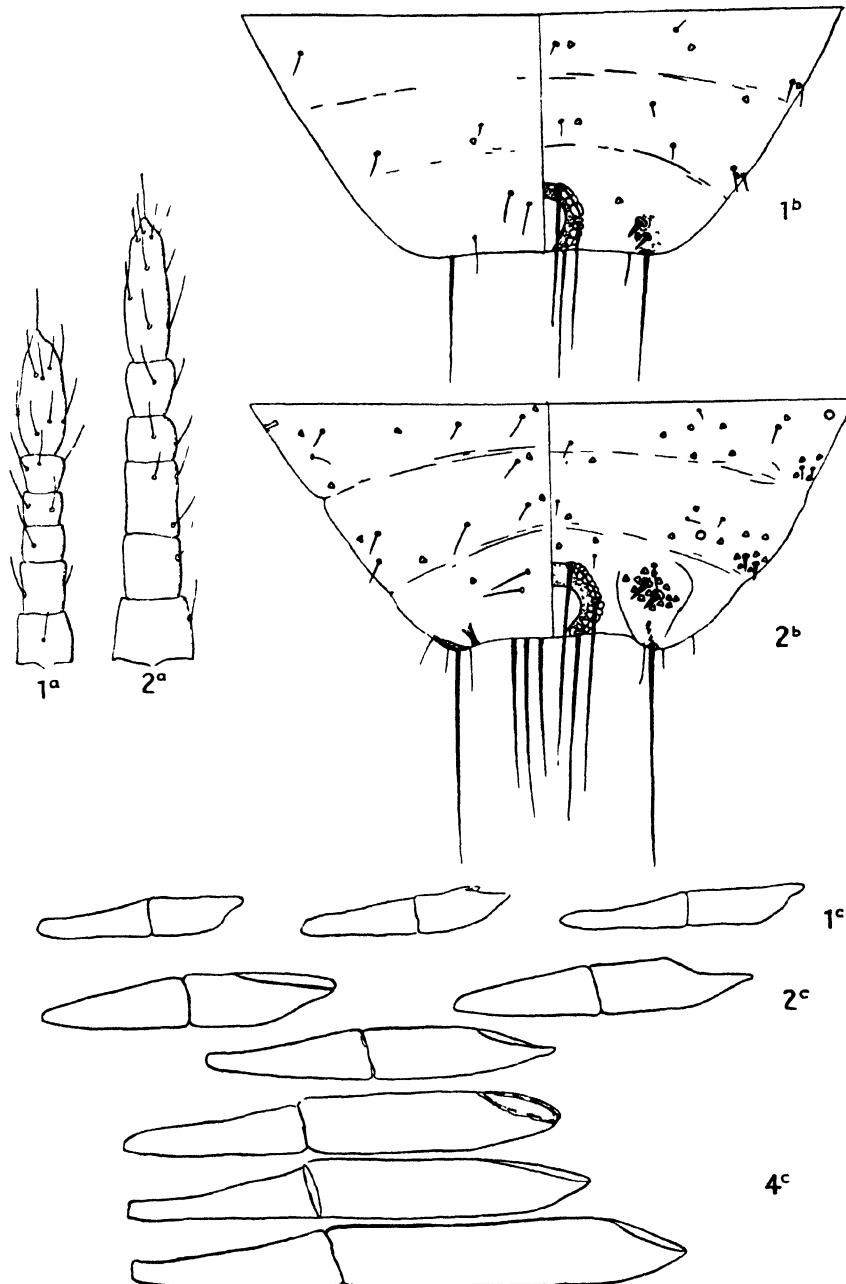


FIG. 1a.—The first instar. An antennae, $\times 150$ diams. 1b.—The first instar. The left side represents the posterior ventral aspect of the abdomen and the right side the posterior dorsal aspect of the same, $\times 150$ diams. 1c.—Outlines of the tibiae and tarsi of the fore, mid, and hind limbs of the first instar, $\times 150$ diams.

FIG. 2a.—The second instar ♀. An antennae ♀, $\times 153$ diams. 2b.—The second instar. The left side represents the posterior ventral aspect of the abdomen and the right side the posterior dorsal aspect of the same, $\times 150$ diams. 2c.—The second instar ♀. The outlines of the tibiae and tarsi of the fore, mid, and hind limbs, $\times 150$ diams.

FIG. 4c.—The third instar ♀. The outlines of the tibiae and the tarsi of the fore, mid, and hind limbs showing relative lengths of tibiae and tarsi, $\times 150$ diams.

0.28 mm. to about 0.90 mm. in width at the first ecdysis. The body outline as seen from above is nearly ovoid, though the cephalic end is more rounded. The derm soon becomes covered with a waxy dust which gives the body a paler shade of yellow, and two short anal tassels are soon secreted from the region of the paranal cerarii. The eyes in life appear as dark dots at the bases of the antennae, and in mounted preparations are seen to consist of a pair of simple circular slightly convex lenses.

The antennae (fig. 1a) are six-segmented and the lengths of the segments (in microns) varied as follows in forty specimens : (1) 20.24-23.36, (2) 20.37-23, (3) 17.11-17.27, (4) 13.17-17.28, (5) 16.98-17.12, (6) 53.23-60.31, with average proportions of (1) 22.13, (2) 22.17, (3) 17.22, (4) 16.38, (5) 17.07, (6) 57.67. Only one type of dermal waxpore, the triangular, is present, and it is sparsely but generally distributed; the cerarii consist of pairs of setae hardly distinguishable from body setae, and each pair is associated with not more than one triangular pore (fig. 1b). The paranal cerarii, however, possess pairs of conical spines, and it is a specific peculiarity that they are markedly unequal in size. The anal lobes are not well developed, but the area around each paranal cerarius is somewhat sclerotised and caudal setae are present. The anal ring consists of a double row of beaded cells which are somewhat unequal in size, and six anal ring setae are present.

The three pairs of limbs are complete and are characterised in this instar by the tarsi exceeding in length the tibiae to which they are attached (fig. 1c) as the following figures (in microns) from forty individuals show.

Fore limb.	Tibiae	varied from	36.67	to	46.62	average	41.81
	Tarsi	"	43.36	to	56.71	"	53.42
Mid limb.	Tibiae	"	40.13	to	46.24	"	44.84
	Tarsi	"	50.23	to	56.58	"	54.67
Hind limb.	Tibiae	"	40.37	to	56.28	"	53.31
	Tarsi	"	50.32	to	63.37	"	59.27

Each leg possesses a pair of ungual and tarsal digitules, the former being slightly longer than the claw and with club-shaped extremities; the tarsal digitules are longer than the unguals. There are two pairs of spiracles of equal size situated in the thoracic region on the ventral aspect; their four stigmatic orifices each measure 5μ in diameter. The rostrum is dimerous and the proximal segment varies in length from 13.29 to 16.65 μ and the distal segment from 30 to 33.34 μ .

The presence of dorsal ostioles could not be traced, but possibly their outlines were too faint to be recognised, but an ovoid ventral cicatrice was very distinctly indicated. The body setae are short and sparse, and most of them are closely associated with a single triangular pore as in the case of cerarian setae. No indication of sex could be detected either in life or in mounted specimens, and it appears that the sexes are indistinguishable externally in this instar.

(b) *The second female instar.*

In life the second larval instar differs little externally from the first instar apart from the fact that the waxy coating is somewhat denser, the anal tassels are longer and a few long glassy filaments of wax project here and there from the body surface. The measurement of mounted preparations shows that the size varies from 0.60 mm. to 0.96 mm. in length and from 0.30 to 0.40 mm. in maximum width.

Although the antennae of this instar are six-segmented as in the preceding stage they can readily be distinguished by the fact that the third segment is markedly longer than either segments four or five (fig. 2a), whereas the third, fourth and fifth segments of an antennae of the first instar are equal or subequal.

The antennal segments of the second female instar vary in length as follows in forty specimens (in microns): (1) 26.62-33.12, (2) 23.27-33.33, (3) 30.21-36.71, (4) 20.18-23.42, (5) 23.48-26.12, (6) 63.25-70.11, with the following average proportions, (1) 29.54, (2) 28.62, (3) 33.45, (4) 22.67, (5) 25.36, (6) 67.82.

In this instar the tarsi instead of being markedly longer than the tibiae as in the first instar are equal or subequal to the tibiae in the prothoracic pair of limbs, and the tibiae are appreciably longer than the tarsi only in the hind pair (fig. 2c), as the following figures (in microns) from forty specimens show.

Fore limb.	Tibiae	varies from	63.35 to	70.47	average	65.43
	Tarsi	"	63.30 to	70.52	"	65.24
Mid limb.	Tibiae	"	66.79 to	73.24	"	69.71
	Tarsi	"	63.56 to	70.13	"	67.45
Hind limb.	Tibiae	"	80.24 to	86.78	"	84.37
	Tarsi	"	73.38 to	80.41	"	78.73

There are seventeen pairs of cerarii, the number characteristic of the adult stage, and conical spines occur on the penultimate as well as on the paranal cerarii (fig. 2b); the triangular dermal waxpores have a denser distribution than in the preceding instar, and there is always more than one waxpore associated with each paranal cerarius. In addition to the triangular pores there are also present a few cylindrical ducts, 3.33μ in diameter, from which arise the glassy filaments of wax already referred to.

The rostrum is dimerous and the proximal segment varies in length from 13.32 to 16.60 μ , and the distal segment from 43.33 to 46.66 μ in length. The dorsal ostioles are clearly demarcated and the ventral cicatrice is similar in shape to that of the preceding instar.

(c) The second male instar.

The second male instar immediately before it begins the formation of the pupal cocoon is longer, narrower, and the body content is darker than a full-grown specimen of the corresponding instar of the female. In mounted specimens, however, owing to the flattening they usually undergo and owing to the disappearance of the body contents, the separation of the sexes would not be easy were it not that the male has a considerable number of circular dermal pores, measuring 6μ in diameter, which are peculiar to that sex and are most probably concerned with the elaboration of the pupal cocoon (fig. 3).

The antennae are six-segmented as in the female and their relative lengths do not depart to a significant extent from those of the female. The following is the variation in length (in microns) exhibited by 40 individuals: (1) 26.72-31.29, (2) 26.61-30.42, (3) 32.97-33.14, (4) 16.62-23.24, (5) 20.12-26.52, (6) 61.66-63.24, and the average lengths are (1) 28.22, (2) 28.81, (3) 33.05, (4) 21.25, (5) 23.42, (6) 62.62.

The relative lengths of the tibiae and tarsi approximate fairly closely to those of the female, but the tibiae are rather longer in relation to the tarsi, as the following figures (in microns) show.

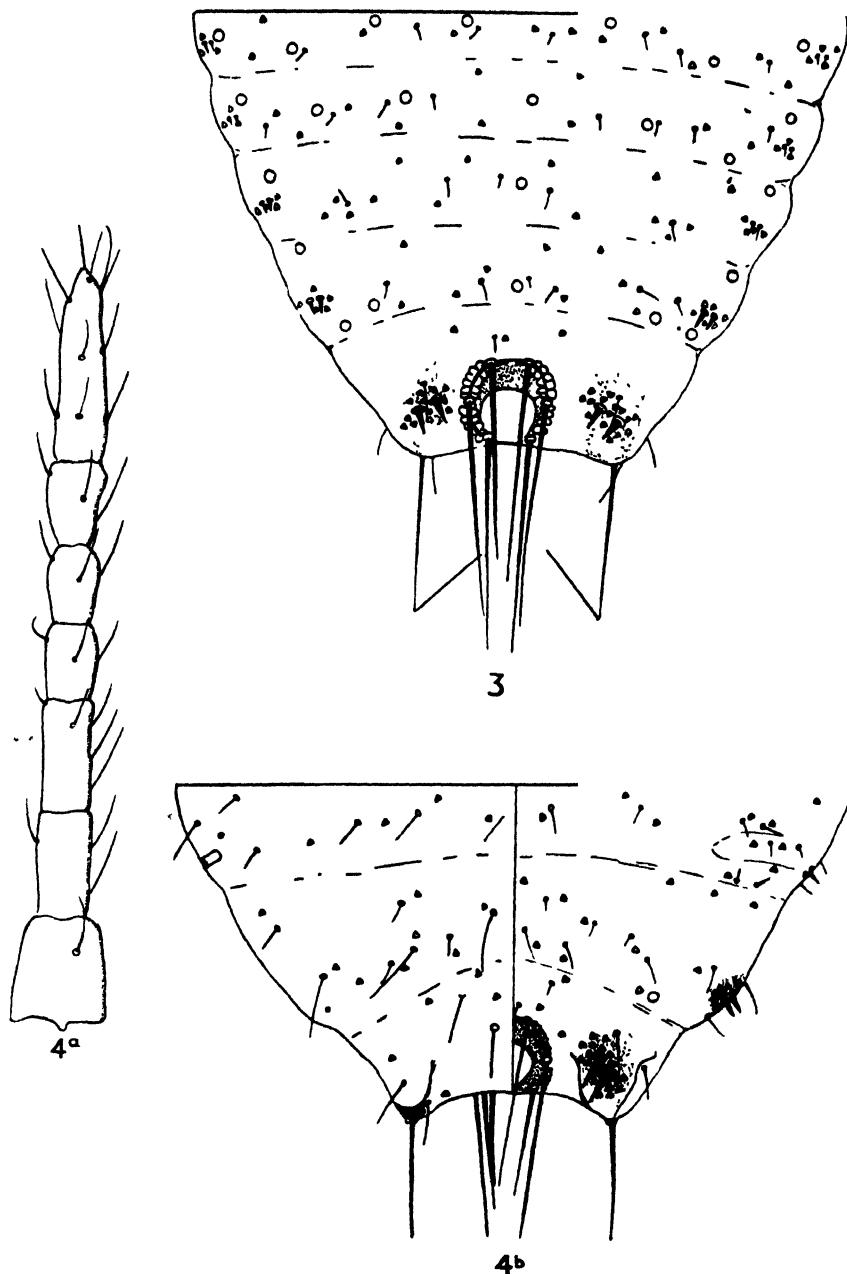


FIG. 3.—The second instar ♂. The posterior dorsal aspect of the abdomen $\times 150$ diams.

FIG. 4a.—The third instar ♀. An antenna, $\times 150$ diams.

4b.—The third instar ♀. The left side represents the posterior ventral aspect of the abdomen and the right side the posterior dorsal aspect of the same, $\times 150$ diams.

Fore limb.	Tibiae	varies from	66.62 to 71.40	average	68.50
	Tarsi	"	61.24 to 67.77	"	66.47
Mid limb.	Tibiae	"	67.34 to 71.57	"	70.53
	Tarsi	"	65.74 to 69.10	"	66.38
Hind limb.	Tibiae	"	83.54 to 87.95	"	86.67
	Tarsi	"	67.37 to 72.42	"	70.53

The length of full-grown specimens varies from 0.99 mm. to 1.12 mm.

(d) *The third female instar.*

The external appearance of the third female instar is very similar to that of a young adult. The marginal tassels are well developed and they increase in length posteriorly, with the hindmost pair markedly longer as in the adult. In life the third female instar can be distinguished from the young adult under the microscope by its shorter and stouter antennae. Usually it is not possible to count the segments of the antennae in life owing to the debris adhering to them.

The antennae are seven-segmented and their lengths (in microns) vary as follows in forty specimens : (1) 43.33-46.62, (2) 40.11-47.73, (3) 40.37-47.67, (4) 26.27-36.38, (5) 30.62-36.19, (6) 30.28-40.32, (7) 73.47-86.28, with average lengths of (1) 44.37, (2) 44.33, (3) 45.12, (4) 32.02, (5) 33.21, (6) 35.27, (7) 80.24 (fig. 4a).

There are two pairs of ventral thoracic spiracles and the anterior pair is smaller as its peritremes vary from 10 to 12 μ in diameter, whilst those of the posterior pair vary from 12 to 14.3 μ .

The rostrum is dimerous and its proximal segment measures from 30 to 40.24 μ and its distal segment from 76.25 to 90.00 μ . The cerarii are even better demarcated than in the preceding instar, the cerarian spines being stouter and the aggregations of associated pores larger; furthermore, dermal pores both circular and triangular are more numerous and the dermal vestiture longer and fuller (fig. 4b).

The seven-jointed antennae, the absence of the genital pore and its attendant circular multilocular dermal pores clearly distinguish this instar from adult females. The third female instar varies in length from 0.90 mm. to 1.20 mm.

(e) *The third male instar or " prepupal " stage.*

After the pupal cocoon is almost completed an ecdysis occurs and a pupiform creature is revealed whose principal characteristics are a small pair of external wing-buds in the mesothoracic region, the absence of mouth-parts and a true anal ring (fig. 5).

Although the climb claws are relatively long and slender and digitules are absent the limbs are capable of slow perambulation. Triangular dermal pores which are present in the two preceding stages of the male and in all the stages of the female, are absent. The characteristic dermal pore is circular and 5.6 μ in diameter; there are also tubular dermal ducts of two-size categories which measure 3.6 μ and 2.6 μ respectively. The body vestiture is short and sparse. The " prepupal " stage varies from 0.90 mm. to 1.20 mm. in length.

(f) *The fourth male instar or " pupal " stage.*

The fourth male instar is characterised and easily recognised by the pair of elongated wing-cases into which the wing-buds of the previous instar have grown. The absence of mouth-parts, triangular dermal pores and anal ring

are also features of this instar (fig. 6). Circular pores of a pattern and calibre similar to those of the third male instar are present, as are also a number of tubular ducts measuring 3.60 μ .

The "pupa" is capable of slow movement, but the tarsi and claws are relatively long and slender, only slightly curved and without digitules. Both "pupa" and "prepupa" are capable of secreting new cocoons if removed from the old ones.

(3) Characters common to the pre-adult instars of *Pseudococcus* spp. (*sens. str.*).

(a) *The first instar.*

The examination of the first instar forms of a considerable number of species of *Pseudococcus* (4, 5, and 6) and their comparison with those of *longispinus*, the genotype, showed the following characters to be distinctive of the first instar forms of *Pseudococcus* spp. (*sens. str.*).

(1) The tarsi of all three pairs of limbs longer than the tibiae to which they are attached.

This character is plainly evident in all the very numerous first-instar forms examined by me. The figures indicating the relative length of tibiae and tarsi have already been given for *longispinus* (sect. 2a), and similar measurements (in microns) are here given for the species *P. citri* Risso and *P. lilacinus* Ckll.

P. citri (40 specimens).

Fore limb.	Tibiae	varies from 40.34 to 43.36	average 42.38	
	Tarsi	" 46.77 to 53.91	" 50.73	
Mid limb.	Tibiae	" 40.57 to 46.68	" 44.21	
	Tarsi	" 50.78 to 53.49	" 51.23	
Hind limb.	Tibiae	" 46.83 to 53.80	" 49.61	
	Tarsi	" 55.31 to 57.12	" 56.14	

P. lilacinus (40 specimens).

Fore limb.	Tibiae	varies from 40.72 to 43.35	average 41.32	
	Tarsi	" 46.61 to 50.81	" 52.19	
Mid limb.	Tibiae	" 40.17 to 46.38	" 42.29	
	Tarsi	" 50.21 to 53.96	" 52.17	
Hind limb.	Tibiae	" 50.72 to 53.28	" 51.52	
	Tarsi	" 56.23 to 60.71	" 57.86	

(2) The triangular-shaped pore is the only type of dermal waxpore present.

(3) The antennae are six-segmented and segments three, four and five are equal or subequal.

(4) Conical cerarian spines confined to the paranal cerarii.

(5) Not more than one waxpore associated with each cerarius.

(b) *The second female instar.*

The following characters are common to the second female instar forms of *Pseudococcus* spp. (*sens. str.*).

(1) The tibiae and tarsi of each pair of limbs do not differ markedly in length. Usually they are equal or subequal in the prothoracic pair and the tibiae are only slightly longer than the tarsi in the hinder pairs.

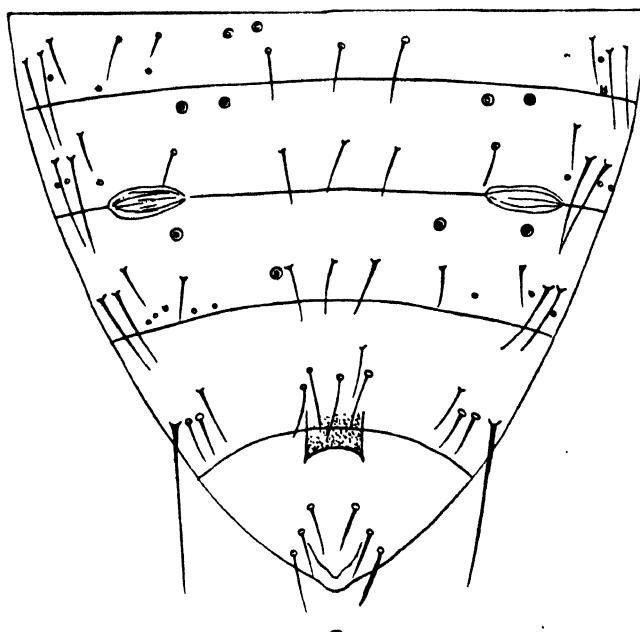
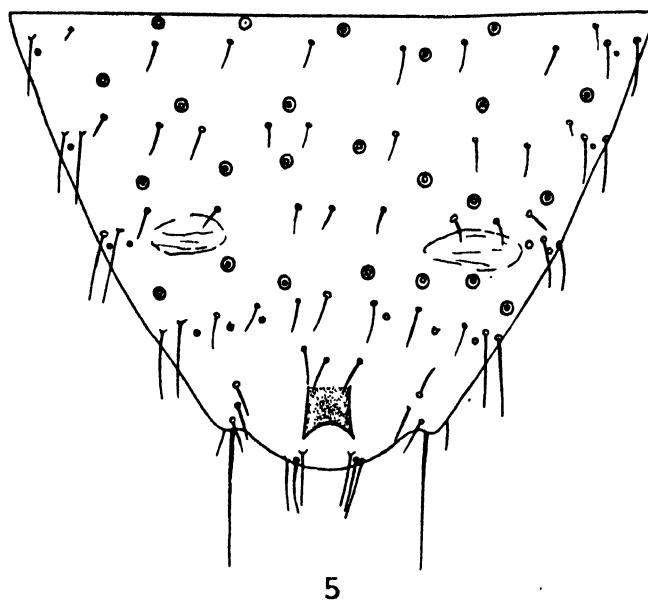


FIG. 5.—The third instar ♂ or the "prepupa" showing the dorsal aspect of the abdomen, $\times 140$ diams.

FIG. 6.—The fourth instar ♂ or the "pupa" showing the dorsal aspect of the abdomen soon after the "pupal" ecdysis, $\times 140$ diams.

The measurement of the fore limbs of *P. citri* and *P. lilacinus* resulted as follows :—

P. citri (40 specimens).

Fore limb.	Tibiae varies from 53.24 to 56.37 average 55.73
	Tarsi , , 56.37 to 61.39 , 57.29

P. lilacinus (40 specimens).

Fore limb.	Tibiae varies from 53.71 to 60.24 average 58.10
	Tarsi , , 58.39 to 63.47 , 60.73

(2) Usually, though not invariably, only the triangular type of dermal waxpore is present. In *P. longispinus* a few large dermal tubular ducts are present in the second female instar.

(3) The antennae are six-segmented and the third segment is markedly longer than the fourth and the fifth segments, which latter two are equal or subequal.

(4) Conical cerarian spines not confined to the paranal pair of cerarii.

(5) More than one waxpore associated with each paranal cerarius.

(c) *The second male instar.*

The second male instar of *Pseudococcus* can easily be distinguished from the corresponding stage in the female by the possession of a number of special dermal pores, which are probably concerned with the production of the "pupal" cocoon. This special type of pore varies with the species; in *longispinus* it is of the open-mouthed circular type, but the circular multilocular type is commoner in other species.

(d) *The third female instar.*

The characters common to the third female instar forms of *Pseudococcus* are :—

(1) The antennae are seven-segmented. This feature reliably distinguishes third- from second-instar forms but not necessarily from adult females, which may have either seven- or eight-segmented antennae.

(2) The tibiae of the three pairs of limbs markedly longer than the tarsi. The following figures are measurements (in microns) of the lengths of the tibiae and tarsi of the third female instar forms of *P. citri* and *P. lilacinus*.

P. citri.

Fore limb.	Tibiae varies from 76.32 to 80.52 average 77.25
	Tarsi , , 70.17 to 76.40 , 72.42
Mid limb.	Tibiae , , 83.41 to 93.12 , 90.41
	Tarsi , , 73.57 to 83.71 , 77.56
Hind limb.	Tibiae , , 96.51 to 106.82 , 102.49
	Tarsi , , 80.47 to 90.14 , 87.61

P. lilacinus.

Fore limb.	Tibiae varies from 76.06 to 86.12 average 80.45
	Tarsi , , 60.17 to 73.21 , 67.34
Mid limb.	Tibiae , , 86.62 to 90.53 , 88.37
	Tarsi , , 73.78 to 83.41 , 76.85
Hind limb.	Tibiae , , 100.00 to 106.72 , 103.72
	Tarsi , , 80.45 to 86.34 , 84.57

(3) The absence of the genital pore and its attendant circular multilocular dermal pores is the most reliable character separating third-instar females of *Pseudococcus* from young adult females.

(e) *The "prepupal" and "pupal" instars of the male.*

The "prepupal" and "pupal" instars agree in lacking mouth-parts, triangular dermal pores and a true anal ring. The "prepupa" can always be distinguished from the "pupa" by the much greater development of the wing-cases on the latter.

SUMMARY.

(1) The study of the pre-adult stages of *P. longispinus* Targ., including the egg and their comparison with the immature stages of many other species of *Pseudococcus* (*sens. str.*), has led to the conclusion that three larval instars in the female and four in the male are typical for the genus.

(2) In *P. longispinus* eclosion takes place externally about fifteen minutes after oviposition. The sexes are indistinguishable externally in the first instar, but sexual dimorphism is apparent in the second instar owing to the presence in the male of special dermal pores which are probably concerned with the elaboration of the pupal cocoon.

The external morphology of the pre-adult instars is described, and numerous measurements showed that such characters as the relative lengths of tibiae and tarsi, the relative lengths of the antennal segments, the diameter of the peritremes of the spiracles, and the relative lengths of the segments of the rostrum vary within limits characteristic for each instar.

(3) The following characters were found to be distinctive for the pre-adult stages of *Pseudococcus* spp. (*sens. str.*).

The first instar :—

- (a) Tibiae shorter than tarsi.
- (b) The antennae six-segmented in which segments three, four and five are equal or subequal.
- (c) Conical cerarian spines confined to the paranal cerarii.
- (d) Only one waxpore associated with each cerarius.
- (e) Only one type of dermal waxpore, the triangular, is present.

(4) The second female instar :—

- (a) The tibiae and tarsi of the prothoracic limbs are equal or subequal, and the tibiae of the two hind pairs of limbs not greatly longer than the tarsi.
- (b) The antennae six-segmented and the third segment is markedly longer than the fourth and fifth.
- (c) The conical cerarian spines not confined to the paranal cerarii.
- (d) More than one waxpore associated with each paranal cerarius.
- (e) Usually though not invariably only one type of dermal waxpore, the triangular, is present.

(5) The third female instar has

- (a) The antennae seven-segmented.
- (b) The tibiae of all three pairs of limbs markedly longer than the tarsi.
- (c) The genital pore and its attendant circular multilocular pores are absent.

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(6) The "prepupal" and "pupal" stages are without mouth-parts, triangular dermal pores and a true anal ring.

Small mesothoracic external wing-buds are present in the "prepupa" and elongated wing-cases in the "pupa."

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**CHARAXES EUDOXUS DRURY (LEP.). A REVISION, WITH
DESCRIPTION OF A NEW SUBSPECIES**

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[Read 18th November, 1936.]

WITH PLATES 1 to 5.

Charaxes eudoxus is a West African species with a range through the Belgian Congo into Uganda, the southern Sudan, and the western part of Kenya Colony in the neighbourhood of Mt. Elgon and the east side of Lake Victoria. Generally believed to be rare, it is not so uncommon in Katanga and the Mt. Elgon locality. The females of *eudoxus* are little known, and the opportunity is here taken of figuring and describing each form, except *theresae* Le Cerf, which is only known by three males. A new form has been taken by Mr. T. H. E. Jackson, F.R.E.S., at Katera, in the forest on the Buddu (west) coast of L. Victoria, which is described in this paper: to him and to Dr. V. G. L. van Someren of Nairobi I am greatly indebted for specimens and information.

An effort has been made, with the aid of the *Zoological Record*, to obtain every published reference to the species, and I am greatly indebted to Lord Rothschild, F.R.S., and Mr. J. Levick for allowing me to study the specimens in their collections.

All the specimens in the National collection and in the Hope Department of Entomology at Oxford have been examined also, and the following notes embody the results from 81 males (including Drury's figure) and 16 females.

I am greatly indebted to Mr. Levick for his loan of the fine specimen of the *mechowi* female which is here figured, and to the Keeper of Entomology, British Museum (Natural History), for permission to photograph a female from Angola, and to make a preparation of the genitalia of *Charaxes fallax* Rich. for comparison with those of *eudoxus* forms.

Mr. F. J. Griffin, Registrar of the Royal Entomological Society, very kindly wrote a note on a bibliographical matter which is appended, and also helped by translating German papers.

MALES.

1. *Charaxes eudoxus eudoxus* Drury, 1782.

This, the nominotypical form, is much the rarest, and seems to be best known from Sierra Leone, whence came the original specimen, figured by Drury (1782). There is in the National collection one male, and in the Oxford University Museum one male and one female, from Sierra Leone. Rothschild and Jordan (1900) note that there is "a male from Buea, Cameroons, in Dr. Staudinger's collection; a specimen from Aburi, Ashanti, in the Senkenbergische Museum at Frankfort-on-the-Main." There is also a male at

Oxford without locality data. Holland (1920) notes "three males which I refer to this species. They were taken at Medje . . .": he alludes to *mechowi* as a separate species. Medje is described as "a point near the Nepoko River in the very heart of the forest." The distinguishing feature of this form is the large size and slightly paler, or more yellowish, colour of the orange rufous band of the fore-wing which extends forwards into area 7 where it is well marked, and is broader than in other forms. On the under surface of the hind-wing all specimens I have seen agree with the figures given by Drury (1782) and Jones (1785) in showing a pronounced black centre to the silver streak which crosses the wing from the anterior margin just external to the precostal vein and anterior to the subcostal vein before it branches. Posterior to the subcostal vein this streak may have a black centre in the other forms, but not anteriorly to the subcostal vein. Holland (1920) distinguishes his three specimens from *mechowi* by "the great reduction in width of the silvery bands on the lower surface of the hind-wings." This is not apparent in the three *e. eudoxus* which I have seen. Possibly Holland's specimens are tending towards the aberration *amaurus* (vide infra).

A feature of *e. eudoxus* also seems to be that on the under surface of the fore-wing the two large silver-bordered black spots in area 2, distal to the cell, approach each other posteriorly very nearly, or may even fuse posteriorly as in the male specimen at Oxford captured by Lieutenant Foster, in which they form a comma-shaped patch with its back directed posteriorly and head to the right, the tail extending forwards into the base of area 3. In the female captured by him the spots are only separated posteriorly by the silver borders which have fused, and in the male from an unknown locality the silver borders just fail to touch. (Pl. 1, fig. 1; pl. 2, fig. 1a.) Drury's figure shows them in the least approximated position.

The large black patch on the underside of the hind-wing in area 1b, shown on the left in Drury's figure 4, is of variable appearance: it is produced by the fusion of two spots anteriorly, which sometimes are fused throughout their length. Occasionally incomplete fusion is shown by an area of brownish scales in the centre of the black, and, rarely, the two spots may be discrete. But the appearance of this patch is not a good character by which to separate forms.

Measurements of the bands on the upper surface of the wings were made at definite spots to provide a standard for comparison between the various forms.

The points chosen were as follows: measurements in millimetres.

- A1. Breadth of orange band along vein 1 of f.w.
- A2. " " " " " vein 2 of f.w.
- B1. " " " " " vein 7 of h.w.
- B2. " " " black submarginal band along vein 5 of h.w.

A little difficulty is introduced by a tendency for the orange scales to penetrate into the black along the veins, giving an irregular edge to the black. In such a case if there is a well-marked indentation just along the vein, the points of the measurer were placed at what was judged to be the edge of the black if it had not been indented by the orange along the vein. Similarly, the margin of the black band on the hind-wing is apt to be a little irregular and allowance has to be made.

The following are the measurements at the points indicated in Drury's figure, the two males at Oxford, and one in the National collection.

		A1.	A2.	B1.	B2.
Drury.	.	8	6	6.5	5
Foster's specimen	.	7.5	6	6	4.5
Nc data	.	7	5	5	4.5
Brit. Mus. specimen	.	7.5	6	6	4.5
Means	.	7.5	5.7	5.9	4.6
Maxima	.	8	6	6.5	5
Minima	.	7	5	5	4.5

A puzzling point obtruded itself in connection with early references to this form. Drury's work, published in 1782, contains in the Index the following reference : "Plate 33, Figs. 1, 4. Eudoxus. A variety of Castor. Fab. Mant. P 251." Now the *Mantissa* was not published until 1787. I sought the help of Mr. F. J. Griffin, Registrar of the Royal Entomological Society, for an explanation of this anomaly, and he kindly wrote as follows :—

" 17th July, 1936.

" Drury's book was certainly published in 1782, and Fabricius' equally certainly in 1787. It is therefore most unlikely that Drury could possibly quote a page or species number reference to Fabricius' book. The only work of Fabricius to which I think a reference could have been made is his *Syst. Ent.* 1775, but in this work I can find no reference either to the species *castor* or *eudoxus*. In my opinion the reference in Drury to Fabricius is a 'ghost.'

" I am led to this conclusion by Drury's remark on page iv of his preface in which he says 'the truth is the descriptions were made about the year 1775. . . .'

" According to Weiss, 1927, *Ent. News*, 38 : 209, Drury first met Fabricius in 1767, Fabricius being then in London, and from 1772-1775, when Fabricius spent his summers in London, Drury frequently met him. It seems, therefore, that Drury had certain specimens in his collection named either *castor* or *eudoxus*, and to his knowledge Fabricius made notes with regard to these specimens. Probably Drury was under the impression that Fabricius had published remarks concerning these specimens, and this is the more likely since in his preface referred to above he complains of the action of entomologists who, while receiving his hospitality, abused this by publishing his (Drury's) names in advance of his own work. This complaint is made when he speaks of the long delay in the publication of Volume 3 of his *Illust. Nat. Hist.*, the work with which all the Drury references given above are concerned."

2. *C. eudoxus mechowi* Rothschild, 1899.

Described from northern Angola : also known from Cameroons (Holland, 1920; Schultze, 1916, 1917) and the Congo as far as Katanga and the Semliki river (Rebel, 1914; Poulton, 1929). The orange-rufous band of the fore-wing decreases rapidly from the inner margin forwards and, according to Rothschild and Jordan who published the first written description in 1900, stops at vein SC 5 (= 7). The black submarginal band of the hind-wing is typically narrower than the admarginal band, and thus narrower than in *e. eudoxus* : it tapers strongly posteriorly. Thus the marginal tawny border is broader than in *e. eudoxus* or *e. cabacus*. It is difficult to find a character of the under surface by which to distinguish *mechowi* from *eudoxus* : the two males of the latter at Oxford are not alike in the character of the black markings in area 1b on the fore-wing, for in the specimen without data the two spots have

not fused, though posteriorly they are nearer together than in *mechowi*. There seems to be one feature, however, by which *mechowi* and all other forms differ from *eudoxus*: the black centre to the discal silver streak present in *eudoxus* anteriorly to the subcostal vein, in *mechowi* and others is absent, as well as in *Ch. fallax* Richelmann. Pl. 1, fig. 2; pl. 2, fig. 2A.

Neave (1904) described a specimen from the Tiriki Hills, Kenya Colony, as belonging to this form. This specimen, however, is in reality of the form *cabacus* described by Jordan (1925).

The race *mechowi* extends eastwards into southern Sudan. A specimen in the possession of Captain I. G. Owen of the Sudan Defence Force, who kindly let me examine it, was taken by him on the western border of the south of Bahr-el-Ghazal, near the French border, on 16 April, 1936, at Bendi, about forty miles south-west of Yambio. Still more interesting is a specimen in the National collection captured by Major F. Moysey in Mongalla Province, on the Imatong mountains lying along the Sudan-Uganda frontier, in 1930. This specimen, belonging to the Congo race *mechowi* and not the East African race *cabacus*, exemplifies again the West African character of the fauna of the South Sudan to which I have previously drawn attention (1935). Both the Sudan specimens are of the aberration *amaurus* Poult. (vide infra).

I am unable to confirm that in *mechowi* the silvery markings are generally less than in *eudoxus*, nor do I agree with the view of Schultze (1916) that *eudoxus* is nearer to *fallax* than is *mechowi*. The great breadth of the band on the fore-wing, and the black centre to the silver streak on the underside of the hind-wing in *eudoxus*, contradict this. Moreover, the male genitalia are alike in *eudoxus* and *mechowi* and both equally different from those of *fallax*. Schultze (1917) criticises Drury's figure as being like a caricature, and therefore is uncertain whether it represents *eudoxus* or *mechowi*. This is unnecessary: the breadth of the fore-wing band is that of *eudoxus* from Sierra Leone, and not at all like Rothschild's figure of *mechowi* (1899), or Oberthür's figure (1912) of the same form which, as Rebel (1914) and Lathy (1925) point out, was quite unnecessarily re-named "blachieri" by Oberthür (1912).

Schultze mentions as characteristic of *eudoxus*, as contrasted with *mechowi*, a fine network of silver over the red-brown base of the under surface: no such distinction is apparent in the specimens which I have been able to see.

Holland (1920) points out that the figure given by Aurivillius in Seitz (1911) lacks the strong black submarginal markings in areas 1a, 1b, on the underside of the fore-wing. It is in many respects an unsatisfactory figure. Holland, apparently following Aurivillius' description of the plate, separates *mechowi* as a species distinct from *eudoxus*.

The width of the rufous-orange band of the fore-wing and of the rufous-orange and black bands of the hind-wing, on the upperside, enables *mechowi* to be distinguished from the next form *cabacus*, which comes nearest to it. The following are the measurements, as in *eudoxus*.

	A1.	A2.	B1.	B2.
Type specimen from Angola in Mr. Levick's collection	5	3	6	2
18 specimens from Cameroons (Bitje, Ja river, and Sakhayeme district), mean of the whole	5.1	2.4	5.2	2.4
Maxima	7	3.5	7	3
Minima	4	1.5	4	1.5

Another set of 23 specimens is grouped together as follows: Central Belgian Congo and French Congo 10, Katanga and other places in Eastern Congo 13.

	A1.	A2.	B1.	B2.
Mean	5.2	2.6	5.3	2.7
Maxima	7	4	6	4
Minima	3.5	2	4	1
Mean for the whole 42 specimens	5.2	2.5	5	2.5
Maxima " " " . .	7	4	7	4
Minima " " " . .	3.5	1.5	4	1
Two specimens from the Sudan { Bendi . .	7	4.5	6.5	2.5
Imatong . .	5	3	6.5	2

The characteristic anterior narrowing of the orange-red band on the front wing, and the posterior narrowing of the black band on the hind-wing, are clearly shown.

3. *C. eudoxus cabacus* Jordan, 1925.

This was described as differing from *mechowi* by having "on the upper-side the tawny post-discal band of the fore-wing much narrower" and on the hind-wing "the tawny discal band likewise narrower than in *Ch. e. mechowi*, and the black submarginal band broader." The tawny band is darker than in *eudoxus*, agreeing in this with *mechowi*: the larger and better-defined basal tawny area of the fore-wing is also different in *cabacus* and *mechowi* from that of *eudoxus*. Pl. 1, fig. 3; pl. 2, fig. 3A.

The type came from Entebbe, Uganda, on the north shore of Lake Victoria, and the following are the measurements for this and eight other specimens from the same neighbourhood.

	A1.	A2.	B1.	B2.
Type	5	3	5	3
Mean for nine specimens	4.3	2.5	4	4.9
Maxima " " . . .	6	4	6	6
Minima " " . . .	2.5	1.5	3	3.5

According to van Someren (1936, 181) "this race extends [from Uganda, central] eastwards to Elgon, Kitale, Cherangani, and the Mau." The following are the measurements in fifteen specimens from the eastern area, including the Yala river and Tiriki Hills.

	A1.	A2.	B1.	B2.
Mean for fifteen specimens	5.8	3.5	5.7	4.2
Maxima " " . . .	7	4	8.5	5
Minima " " . . .	5	2.5	4.5	3

It will be seen that in the Entebbe neighbourhood the fore-wing band is narrower than in the eastern examples, in which the anterior end is noticeably larger, so that in this respect the eastern examples differ more from *mechowi* which has the band much less marked anteriorly, though it is broader posteriorly than in most *cabacus* from the type locality. It is interesting that there should be this difference between eastern *cabacus* and those from the more western locality of the type; some of the latter come quite near to the new subspecies described below as *katerae* from a locality further west, on the west coast of the northern part of Lake Victoria.

If the tables be compared with those for *mechowi*, the posterior narrowing of the submarginal black band on the hind-wing of the latter is evident.

4. *C. eudoxus cabacus* ab. *amaurus* Poulton, 1929 (= *eudoxus amaurus*).

This was differentiated by the "dimming of the characteristic silvery pattern of the under surface in other races of *eudoxus*." The type, and female

allotype, in the University Museum at Oxford, came from Kenya Colony, Kitale, on the south-east lower slopes of Mt. Elgon. Allusion is made to another specimen captured at Kamwezi and described by Neave (1904) as a form of *mechowi* in which "the silvery marking of the underside has entirely disappeared, and is only partly replaced by a dull slate-colour." This is the maximal development of this aberration. The markings of the upper surface do not appreciably differ from those of specimens of normal *cabacus* from the same area, but it is interesting that no specimens of the aberration *amaurus* have yet been seen from the Entebbe neighbourhood. Pl. 1, fig. 4; pl. 2, fig. 4A.

The following are the measurements in seven specimens of the aberration, all from the Elgon neighbourhood.

		A1.	A2.	B1.	B2.
Type	.	5.5	4	5	4
Mean, of seven	.	5.3	3.8	5.8	4.3
Maxima	:	6	4	7.5	5
Minima	.	5	3.5	5	3.5

The form *amaurus* can no longer be regarded as a geographical race; it appears to be an alternative of the under surface which occurs in other races as well as in *cabacus* (e.g. the Sudan *mechowi* mentioned above, and the race *katerae* described below). It would be most interesting to ascertain whether it ever occurs in *e. eudoxus* of the West Coast. (Vide supra under *e. eudoxus*.)

The question of *amaurus* as a race distinct from *cabacus* was considered by van Someren (1936, 182); he "bred a series of both from the same locality, and it would appear that *amaurus* is a variety and not a geographical race." The life-history is described and "the early stages appear to be identical, or almost so." The pupa of *amaurus* according to the description has "a yellowish streak on the edge of the wing-cases and spots of the same colour on the head" which are apparently not present in *cabacus*.

5. *C. eudoxus theresae* Le Cerf, 1932.

This was described from a single male, taken at Kitembo, Lake Kivu: it was considered to be intermediate between *mechowi* and *cabacus*. In the holotype (pl. 5, fig. 1) the chestnut basal area of the fore-wing extends to the discocellular. The character of the postmedian band is peculiar: very wide at the base ("8 mm. entre 1-2") it very rapidly decreases to 2 mm. behind nerve 3, which it does not reach. Beyond nerve 3 there are three spots, of which the last is minute. Marginal spots smaller than in *mechowi* or *cabacus*.

The orange band of the hind-wing measures 10 mm. on nerve 5, and 6.5 mm. on nerve 7, above which it expands strongly towards the base of the wing forming a long point reaching to the base of nerve 8. The post-discal black band measures 8 mm. from nerve 8 to nerve 6, and is narrower between 6 and 2, measuring 4 mm. between 3 and 2.

Since this description Monsieur Le Cerf has received two other specimens from Lake Kivu, and through his great kindness I am able to reproduce, from negatives sent by him, photographs of the holotype and one of the later specimens, differing slightly. (Pl. 5.)

The great basal width of the band on the fore-wing, coupled with its very rapid diminution anteriorly, indicate that *theresae* is nearer to *mechowi* than to *cabacus*: this would be expected from the locality, of which Monsieur Le Cerf wrote to me that it is "un centre faunistique bien différent de ceux du Kenya Territoire." It will be noted that in one specimen (pl. 5, fig. 2) the character

of the black band of the hind-wing is quite analogous to that of *mechowi*, but in the holotype and the other specimen it does not show the rapid narrowing posteriorly. The under surface of *theresae* is like that of *mechowi*. This form is obviously transitional from *mechowi* towards the form described in the next section as *katerae* subsp. n. and the locality is geographically intermediate between the habitats of *mechowi* and *katerae*. No females have yet been taken which can be ascribed to *theresae*.

6. *Charaxes eudoxus katerae* subsp. n.

The type and the two other specimens mentioned below were collected by Mr. T. H. E. Jackson at Katera in 1935, in the Malabigambo forest on the Buddu (west) coast of Lake Victoria. This race is characterised by a much greater reduction of the tawny band on the upper surface of the fore-wing so that it is only faintly shown in areas 1a, 1b, and 2, and can with difficulty be seen to be represented anteriorly by a few scales. The submarginal black band of the hind-wing is large, and not so tapering posteriorly as in *mechowi*; the tawny band of the hind-wing is narrowed and partly suffused with black so as to be darkened. Expanse of fore-wings 67 millimetres. Pl. 1, fig. 5.

Two of the specimens are of the aberration *amaurus*, the silver markings on the under surface being replaced by dull grey; in one specimen they are reduced more than in the other. In the type the silver on the under surface is as brilliant as in *e. eudoxus*; the black centre is lacking in front of the subcostal vein as in all other forms except *e. eudoxus*. In the relative position of the two large black spots on the underside of the hind-wing in area 2 *katerae* resembles other forms of the species except *e. eudoxus*—that is, they do not meet posteriorly. Pl. 2, fig. 5A.

This form greatly resembles *Charaxes fallax* Richelmann in general appearance. Its rather smaller size, less concave outer margin of the fore-wings, intense, almost bluish, deep brownish-black ground-colour, and the darker tawny-orange markings on the upperside, conduce to this resemblance. But the post-discal band on the f.w. is represented in *fallax* by a series of markings of almost equal width from areas 1a to 6 inclusive, more clearly divided from each other, whereas in *katerae* the markings taper to a scarcely visible mark in area 2, beyond which they are not continued in the type. In the two specimens of aberration *amaurus* there is just visible a trace of dark orange in areas 3 and 4. The tawny-orange band on the hind-wing is not quite so narrow as in *fallax*, and at the anal angle in *fallax* the blue spots are much less developed than in forms of *eudoxus*. Pl. 1, fig. 6; pl. 2, fig. 6A.

The width of the bands is as follows:—

		A1.	A2.	B1.	B2.
<i>katerae</i> type	2.5	not perceptible	4.5	8.5
„ ab. <i>amaurus</i>	2	1	4	6
„ „ „	2	1	2.5	5.5
<i>fallax</i> (figured)	3.5	2	2.5	5.5
Means of seven other specimens in B.M.	..	3.6	2.5	4.3	4.7
Maxima	4.5	3	6	6
Minima	3	2	2.5	3.5

It will be seen that on the fore-wing the post-discal orange band is more reduced in *katerae* than in *fallax*. The under surface has several features by which *katerae* can be distinguished from *fallax*. The two large spots in area 2

are some distance apart, as in other forms of the species except *e. eudoxus*, whereas in *fallax* they are contiguous. In area 3 there is a large black spot which in *fallax* is in the middle of the distance between the base of the area and the wavy silvery line which runs back from the costa, delimiting a much darker basal portion of the wing (seen well in fig. 6A). In *katerae*, as in all other forms of the species *eudoxus*, this spot lies more distally and touches the end of the pale line which is much less silvered than in *fallax*. Distally to this silvered line there is in *fallax* a distinct black mark edged with silver distally in each of areas 4, 5, 6, 7, continuing forwards the series commencing in 1a. These black marks are not shown in forms of *eudoxus* in areas 4, 5, 6, 7, and the silver edges are represented by rather indefinite and irregular pale zigzag lines (see pl. 2). The under surface of the hind-wing in *fallax* has the silver streaks finer and narrower than in forms of *eudoxus*. There are three main silver streaks crossing the wing from the costa backwards, of which the proximal is just external to the precostal vein. The other two may be bent towards each other so that they are contiguous in their middle part (as in the figure of *katerae*) or they may not touch (as in the figure of *mechowi*). In *fallax* they are very wide apart, and the distal one is much finer than in any form of *eudoxus*.

This new race *katerae* was first mentioned and figured by van Someren (1936 : 183-4, pls. 22, 23) but no name was given to it, pending the present revision : he drew attention to the occurrence of specimens without the silver markings on the underside.

The general dark tints of *katerae*, with the almost bluish tint in the dark brown, produce considerable resemblance to *Ch. lucretius* Cr.; the lack of silver on the underside of the aberration *amaurus* greatly aids this resemblance. The female of *katerae*, as will be seen, has an astonishing resemblance to that of *lucretius*.

FEMALES.

It now remains to consider the females of *Charaxes eudoxus*.

Aurivillius (1894) mentioned the female as like the male.

Rothschild and Jordan (1900 : 419) describe the female of *e. eudoxus* as "Essentially like ♂, tawny band of fore-wing, above, wider": the female of *e. mechowi* is "not known."

A short description of the female of *e. cabecus* (sic) is given by van Someren (1929 : 175), and the female of the new form, unnamed at that time, was described, with two plates, in 1936 (p. 184). The female of Poulton's *amaurus* was described by him in 1929.

1. *C. eudoxus eudoxus*.

The specimen figured is taken as the neallotype. It is in the Hope Department of Entomology in the Oxford University Museum, and was captured in 1910 at Regent, about three miles south-east of Freetown, Sierra Leone, by the late Lieutenant Chas. A. Foster, whose father generously gave it, among many other valuable specimens, to the University.

The general appearance is sufficiently well illustrated by the figures : the colour of the paler areas above is considerably lighter than in the male. The expanse of wings, between the broadest part of the fore-wings at vein 7, is 85 mm. Pl. 3, fig. 7; pl. 4, fig. 7A.

Measurements in the same manner as for the males give—

	A1.	A2.	B1.	B2.
Neallotype	8	7	6.5	8

The under surface has the same characteristics as that of the male: the silver bars on the hind-wing anteriorly have black centres, and the two large black spots in area 2 are posteriorly very near together, though they do not fuse as in the male.

2. *C. eudoxus mechowi*.

The neallotype is taken as the specimen in the collection of Mr. John Levick of Handsworth Wood, Birmingham, who generously sent it for photography (pl. 3, fig. 9, and pl. 4, fig. 9A). It bears data as follows: "Katanga, Congo B., Kangazi. Coll. Le Moult."

The differences from *e. eudoxus* are the same as in the male: the black admarginal band of the hind-wing rapidly tapers posteriorly, and the marginal tawny border is broader than in *eudoxus*: its black outer edge is narrower so that the centres of the tails are tawny instead of being filled with black as in *eudoxus*. The marginal tawny spots on the fore-wing are larger than in *eudoxus*, and form a band only broken by the black ends of the veins. The black portion of the fore-wing between the tawny band and the basal area, the latter being darker red-brown than the band, is more sharply defined from the basal area, and is without the ill-defined red-brown spots present in *eudoxus* at the end of the cell and at the bases of areas 6 and 7.

The under surface differs from that of *eudoxus* as in the male. The faint trace of black in the centre of the anterior part of the silver streak just external to the precostal vein is rather exaggerated by the photograph. The separation of the two large spots in area 2 is well seen. Expanse of wing 82 mm.

There is a somewhat damaged female in the National collection, formerly in the possession of Mr. Grose-Smith, from whom it was acquired by the late Mr. Joicey: the only datum it bears is "Angola." It agrees with other specimens of *mechowi* here mentioned; on the under surface the silver streak external to the precostal vein of the hind-wing has no trace of silver until that part within the posterior half of the cell. The two spots in area 1b of the fore-wing form one solid, almost quadrangular, mass, and the two in area 2 are brought closer together by the enlargement of the outermost which, nearly spherical, is only separated from the inner one by their silver borders. These points are clearly shown in pl. 4, fig. 8A.

Measurements of available specimens give the following results.

	A1.	A2.	B1.	B2.
1. Neallotype	8	6	6.5	6
2. Also in Mr. Levick's colln., data as 1	9	6	7	3.5
3. " " " " , Katanga, Kangazi	7	6	5.3	3
4. Lord Rothschild's colln., " " "	8	5.5	6	5
5. National collection, "Angola" "	9	6	6	3.5
Mean	8.2	5.9	6.2	4.2
Maxima	9	6	7	6
Minima	7	5.5	5.3	3

It will be seen that the specimen selected as the neallotype does not exemplify so markedly as do some of the others the sudden narrowing posteriorly of the black admarginal band of the hind-wing.

3. *C. eudoxus cabacus*.

The female of this race was not known to Jordan when he described the male. A brief description under the name "cabecus" was published by van Someren (1929). This must be looked upon as the original description of the female, but unfortunately no type specimen was designated, nor were exact data of locality given for the allotype. The female specimens which I have seen all come from the neighbourhood of Kitale, on the south-east slopes of Mt. Elgon.

As the publication is not everywhere accessible this first description is here reproduced.

" *Charaxes eudoxus cabecus*, [sic] Jord.

FEMALE : Very like the male but the fore and hind ala[r] bars are wider and of a paler orange, the spots in the fore-wing being more pronounced and expanded laterally. The marginal spots of both fore- and hind-wings larger and paler. The underside has a paler chestnut ground-colour but the distribution of the markings is as in the male, though less silvery."

This description was later (1936) augmented, and a figure given, which must be considered to represent the allotype. It is unfortunate that this figure shows an approach to *mechowi* in the rather sudden narrowing posteriorly of the black admarginal band on the hind-wing: this is not shown in the figure now given (pl. 3, fig. 10) nor in six other females kindly lent for study by Dr. van Someren. The female of *cabacus* differs from that of *eudoxus* by the narrower black margin to the hind-wing and broader orange band immediately internal to it: thus (as in *mechowi*) the bases of the tails are orange instead of black. The black post-discal band of the hind-wing does not suddenly taper posteriorly, thus agreeing with *eudoxus* and differing from *mechowi*. The fore-wing differs markedly from that of *mechowi* in the breaking up of the black beyond the cell by orange spots in the bases of areas 4, 5, and 6, and again more distally in the same areas: this is the case to a greater degree in the figure given by van Someren than in the one illustrating this paper. These spots are faintly indicated in *eudoxus* but absent from *mechowi*.

The following are the measurements for four specimens of typical female *cabacus* which I have been able to see through the kindness of Dr. van Someren and Mr. T. H. E. Jackson.

	A1.	A2.	B1.	B2.
Means	8.1	6.4	7.1	5.6
Maxima	9	7	9	7
Minima	7	5.5	6.5	5

4. *C. eudoxus cabacus* ab. *amaurus*.

This can no longer be considered as a race, but only as an aberration which may occur in *cabacus*, and also in *mechowi* and *katerae*.

The allotype of *amaurus* described by Poulton (1929) is shown on pl. 3, fig. 11. As in the case of the respective males, there is no difference of importance between *amaurus* and typical *cabacus* on the upperside.

Measurements give the following values.

	A1.	A2.	B1.	B2.
Allotype	8.5	7.5	7	6
Means for three others from Kitale	7	5.3	6.2	6.2
Maxima " " " "	7	7	7	6.5
Minima " " " "	7	5	5	5.5

In the extreme form of *amaurus*, shown in Poulton's female allotype (pl. 4, fig. 11A) and one of the specimens which Dr. van Someren kindly lent me, as Poulton described (1929, 478) : "the suppression of the markings is carried further than in the male, especially in H.W., where a close inspection is required in order to detect the fine grey line which occupies the position of the basal stripe and the slight traces indicating in part the position of the silvery markings crossing the centre of the wing in *cabacus*."

This uniform under surface produces a considerable resemblance, as Poulton pointed out, to the female of *lucretius* Cram., but the *upper* surface has departed little from that of typical *amaurus*. The figures given above seem to indicate that a slight narrowing of the orange bands on the wings has begun; a process carried much further in the next subspecies (*katerae*) to produce an astonishing resemblance to *lucretius*.

The development of the silver streaks in the female of even typical *cabacus* is not so great as in *eudoxus* and *mechowi*. It remains to be seen whether *katerae* occurs in the form *amaurus* in the female sex: the only two specimens known at present have the silver well developed.

5. *Charaxes eudoxus katerae* subsp. n.

The female of the form here named was described and figured by van Someren (1936) as a new subspecies, but he gave it no name. The paratype here figured (pl. 3, fig. 12; pl. 4, fig. 12A) was captured by Mr. T. H. E. Jackson in October, 1935, in the Katera forest (part of the Malabigambo forest) on the west coast of Lake Victoria, Buddu, Uganda. The allotype in the National collection differs slightly from the figure by the bands on the hind-wing. It was captured in the same forest as those taken by Mr. Jackson, by Dr. S. A. Neave in September, 1911.

The appearance, well shown by the figures, is, as van Someren pointed out (*loc. cit.*), very like that of the female of *Charaxes lucretius* Cr., which flies with it in the same locality. This resemblance is due to a darkening of the fore-wing, nearly the whole of which is of a very deep blackish-brown, the basal tawny-orange area being greatly reduced so that it only extends over half of the cell, but leaves a well-marked tawny-orange spot at the end of the cell; to a similar darkening on the hind-wing and broadening of the black post-discal band; and to a narrowing of the pale bands crossing both wings which are of a lighter shade than in other forms of *eudoxus*. The marginal spots on the fore-wings are as small as in *e. eudoxus*; the marginal lunules of the hind-wings are distinctly separated from each other by the black ends of the veins which aid the resemblance to *lucretius*; for in other forms of *eudoxus* the lunules tend to form a continuous band by reduction of the black on the intervening veins. The conspicuous tawny-orange spot on the fore-wing at the end of the cell is matched by a similar marking in *lucretius* which, however, has the proximal half of the costal area more strongly tawny-orange than *katerae*.

The following are the measurements of the discal spots, and the black band on the hind-wing, as before.

			A1.	A2.	B1.	B2.
Paratype	:	:	5	4	4	8.5
Allotype	:	:	5	4	6	6.5

The under surface is conspicuously different from that of *lucretius*, owing to the characteristic silver streaks: there is no essential difference from that

of *cabacus* (see figs. 10A, 12A). No *amaurus* aberration of the female *katerae* is yet known: it would immensely enhance the likeness to *lucretius*. The two large spots in area 1b of the fore-wing are in *katerae* fused into one blotch, which is their usual state, whereas in the specimen of *cabacus* female illustrated they are, rather unusually, completely distinct. In the three other *cabacus* females examined, and in the four *amaurus* females they are more or less fused.

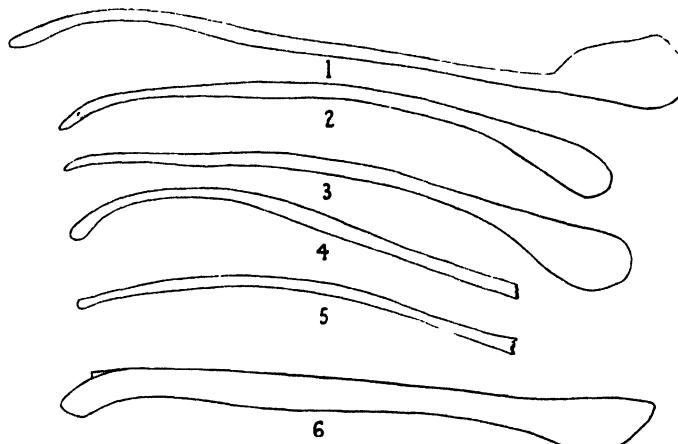
The male genitalia.

Talbot (in Poulton, 1929: 479-80) drew attention to the differences between the genitalia of *eudoxus* forms and *fallax*.

I can entirely endorse his statement that the aedeagus of *fallax* is specifically different from that of *eudoxus*. It is much broader in proportion to its length and has a conspicuous spine, as will be seen from the figure.

I have been unable to examine genitalia of *e. eudoxus*, but have made preparations from 10 specimens of other races, and give drawings which show that those named in this paper, except *theresae* which I have not examined, are undoubtedly conspecific. There are no adequate grounds for separating *mechowi* from *eudoxus* (Holland, 1920), or for Schultze's view (1916) that *eudoxus* is nearer to *fallax* than is *mechowi*. The basal extremity in both specimens of *katerae* is unfortunately missing, but the proportions of the greater part are as in other races of *eudoxus*.

The differences mentioned by Talbot in the apical part of the clasper are of doubtful validity. It is difficult to make sure that a structure of which part is bent at an angle is always seen in the same fashion when drawn under the microscope; and the degree of chitinisation seems to me to vary greatly.



Figs. 1-6.—The aedeagus of *Charaxes eudoxus* and *C. fallax*.—1. *C. eudoxus mechowi*, the figured specimen; 2. *C. e. cabacus*, the figured specimen; 3. *C. e. c. ab. amaurus*, holotype; 4. *C. e. katerae*, holotype; 5. *C. e. k. ab. amaurus*, holotype; 6. *C. fallax*, the figured specimen.

It seems possible, from the foregoing data, to distinguish the following races of *Charaxes eudoxus*:

1. *eudoxus*. The most westerly; known from Sierra Leone, Ashanti, Buea (Cameroons); and "Medje, near the Nepoko river in the very heart of the forest," Congo Belge.

2. *mechowi*. Known from northern Angola and the Belgian Congo including Katanga and other parts of the eastern Belgian Congo as far as the Semliki river. One specimen is known from the mountains on the Sudan-Uganda border in Mongalla Province, another from the Sudan near the French border in Bahr-el-Ghazal Province.
3. *theresae*. Three specimens, from Lake Kivu.
4. *katerae*. At present only known from the Malabigambo forest at Katera, in Buddu, Uganda, on the west coast of Lake Victoria.
5. *cabacus*. Extends from Entebbe on the north coast of Lake Victoria through the Tiriki Hills to Mt. Elgon, Cherangani, and the Mau plateau.

It is interesting that the darkest race, *katerae*, is not found on the West Coast nor in the Congo, but on the N.W. shores of Lake Victoria. The climate here is certainly very humid, the rainfall being of the order of up to 75 inches per annum, and there being no definite dry season.

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PLATE 1.

Males. Upper surface.

FIG. 1. *Charaxes eudoxus eudoxus* Drury.
Regent, near Freetown, Sierra Leone. *C. A. Foster*, 1910.

2. *C. e. mechowi* Rothschild.
Belgian Congo, Basankusu, 25 miles west of Bongandanga, Bafaka. *Miss G. Vinall*, 26 June, 1929.

3. *C. e. cabacus* Jordan.
Lake Victoria, N.E. shore, Tiriki Hills, 20 miles north of Kisumu, 5100 feet. *C. A. Wiggins*, 1 March, 1903.

4. *C. e. cabacus* ab. *amaurus* Poulton. Holotype.
Kenya Colony, eastern slopes of Mt. Elgon, west of Kitale, 6-7000 ft. *V. G. L. van Someren*, 24 April, 1924.

5. *C. e. katerae* subsp. n. Holotype.
Uganda, N.W. shore of Lake Victoria, Buddu coast, Malabigambo forest, Katera, c. 4000 ft. *T. H. E. Jackson*, October, 1935.

6. *C. fallax* Richelmann.
Cameroons, Ja River, Bitje, 2000 ft. *G. L. Bates*. In British Museum ex Bethune-Baker collection.

Specimens 1 to 5 are in the Hope Department of Entomology, University Museum, Oxford.

PLATE 2.

Males. Under surfaces.

FIGS. 1A to 6A. Data as for corresponding numbers in Plate 1. The same specimens.



ENGRAVED BY STAR ILLUSTRATION LONDON

Males of *Charaxes*.



ENGRAVED BY STANFILL ILLUSTRATION LONDON

Males of *Charaxes*.

PLATE 3.

Females. Upper surfaces.

FIG. 7. *Charaxes eudoxus eudoxus* Drury. Neallotype.

Data as for 1.

8. *C. e. mechowi* Rothschild.

Angola. In British Museum ex Joicey collection.

9. *C. e. mechowi*. Neallotype.

Belgian Congo, Katanga, Kangazi. Coll. Le Moult. In the collection of Mr. John Levick, Birmingham.

10. *C. e. cabacus* Jordan. Neallotype.

Kenya Colony, Mt. Elgon. *T. H. E. Jackson*, August, 1932.

11. *C. e. cabacus* ab. *amaurus* Poulton. Neallotype.

Data as for 4.

12. *C. e. katerae* subsp. n. Paratype.

Data as for 5. In the collection of Mr. T. H. E. Jackson of Kitale.

Nos. 7, 10, 11 are in the Hope Department of Entomology in the University Museum, Oxford.

PLATE 4.

Females. Under surfaces.

Figs. 7A to 12A. Data as for corresponding numbers on Plate 3. The same specimens.

PLATE 5.

Charaxes eudoxus theresae Le Cerf.

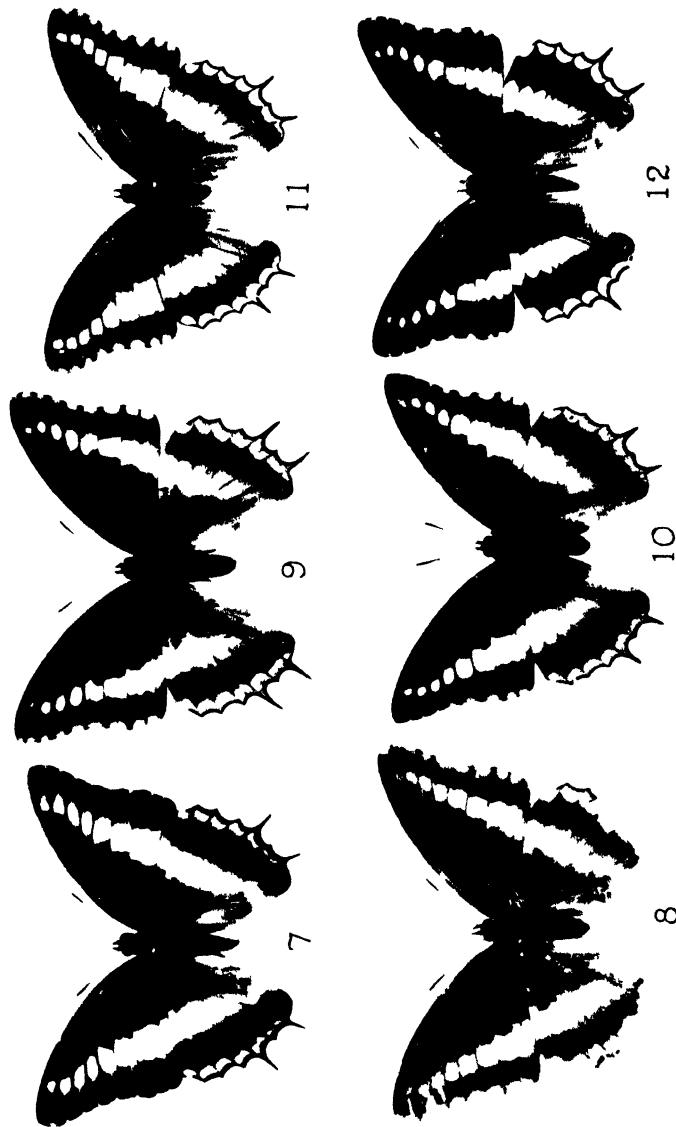
FIG. 1. ♂ Holotype.

Eastern Belgian Congo, Lake Kivu, Kitembo. Guy Babault, July, 1931.

2. ♂, transitional from *mechowi* Rthsch.

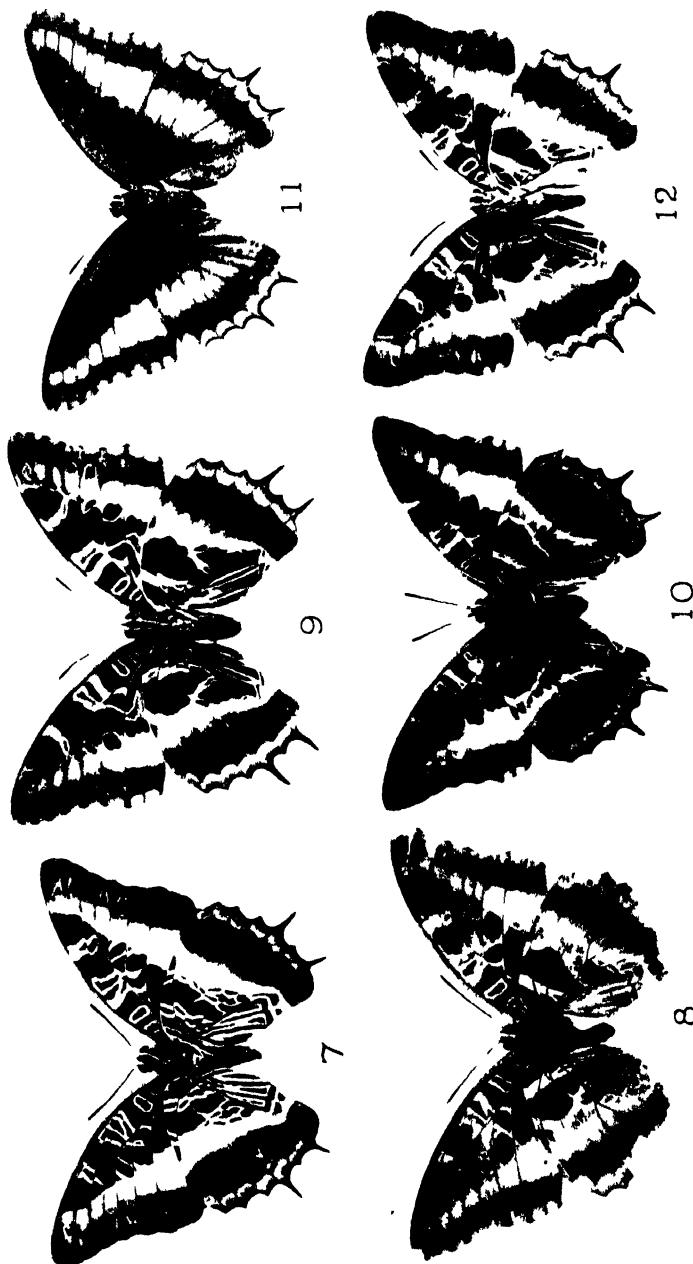
Lake Kivu, Bulira, Kitembo. Guy Babault, February, 1934.

Photographs by courtesy of Monsieur Le Cerf, Muséum national d'Histoire naturelle, Paris.



INCRAVII BY T&R ILLUSTRATION LONDON

Females of *Charaxes eudoxus*

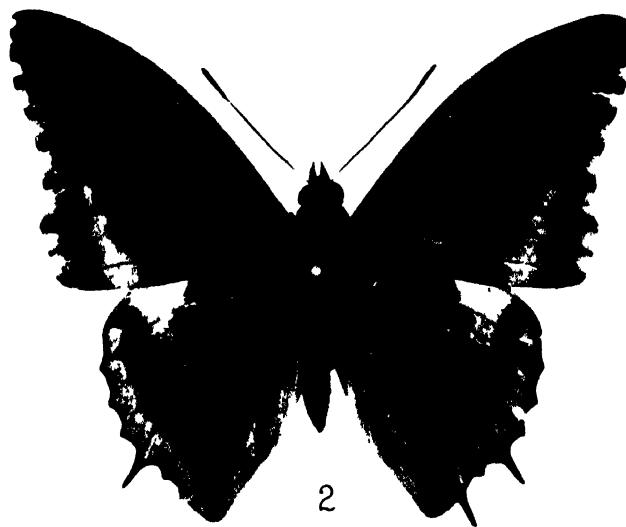


ENGRAVED BY STAR ILLUSTRATION, LONDON

Females of *Charaxes eudoxus*.



1



2

GRAVED BY STAR ILLUSTRATION, LONDON.

Males of *Charaxes eudoxus*.

RESULTS OF THE OXFORD UNIVERSITY EXPEDITION TO BRITISH
GUIANA, 1929. HYMENOPTERA, SPHECIDAE AND BEMBECIDAE

By O. W. RICHARDS, M.A., D.Sc.

[Read 18th November, 1936.]

WITH PLATE 1.

THE following notes are based partly on the material obtained by the Oxford University Expedition (now in the British Museum collection), partly on other material preserved in the British Museum.

SPHECIDAE.

Ammophila Kirby.

1. *A. abbreviata* (Fabricius, 1805).

♀ — *guyana* Cameron, 1912; ♂ = *oxystoma* Cameron, 1912.

The types of Cameron's supposed species, which were described from British Guiana, are preserved in the British Museum. I have examined the following further specimens from British Guiana:—♀ (*Rodway*); Essequibo R., Moraballi Creek, ♀ 23 Sept. '29, ♂ 18 Sept. '29 (O.U. Exped.); ♀ N.W. District, Yarikita Passage, Feb. '17 (*G. E. Bodkin*). The two O.U. Exped. specimens were both captured in dark forest.

2. *A. opulenta* (Guérin, 1830).

(= *lobirollis* Cameron, 1912).

The type of Cameron's species, which was described from British Guiana, is preserved in the British Museum. I have examined the following further specimens from British Guiana:—♀ (*Rodway*); Essequibo R., Moraballi Creek, ♂ on trail, 12 Nov. '29, ♀ dark forest, 24 Sept. '29 (O.U. Exped.). The last-named specimen was detected by hearing the rustling sound the female made as she walked over dead leaves at the edge of the path, dragging a thick green caterpillar rather longer than herself. It was carried upside down, head foremost, being held by the jaws of the wasp only, gripped at the third pair of legs. It was dragged for fifteen feet, the wasp walking all the time. She then left it and circled about for one minute, visiting the nest which was twelve feet away. She then came back and fetched the caterpillar. During her progress she was quite silent, except for a slight buzz whenever she slipped. The caterpillar was laid down at the mouth of the burrow and she entered the nest to take out the temporary stopper. This was made of small bits of leaf, stick, and roots and was at a depth equal to her own length from the entrance. In clearing out the stopper, she flew with the pieces and dropped them about three feet away. She now seized the caterpillar by the prothorax and dragged it in. It became entangled with some projecting roots and the wasp came out and spent some time in vainly trying to tear the roots away. Finally she bit off their end portions and used them later for filling in the nest. The

burrow was half an inch in diameter, but excavation failed to discover the cell or the prey. The latter was perhaps a tailless Sphingid larva, green with red stripes at the sides.

3. *A. fragilis* Smith, 1856.

(= *pilimarginata* Cameron, 1912).

The type of Cameron's species, which was described from British Guiana, is preserved in the British Museum; it was compared with Smith's type.

Chlorion Latreille.

4. *C. viridicoeruleum* Lepeletier, 1825.

(= *hemiprasinum* (Sichel, 1863)).

Cameron (1912) recorded this species from British Guiana under Sichel's name. I have examined his specimen and also another collected by Rodway; both are females. Girard (1879 : 967) says that this species preys on cockroaches in the Antilles and Guiana.

Priononyx Dahlbom.

5. *P. thomae* (Fabricius, 1775).

I have examined one female of this species from British Guiana, N.W. District, Issororo, Aug. '17 (G. E. Bodkin).

The biology of *P. thomae* has been studied by Hartmann (1905 : 62), Williams (1913 : 227) and Rau (1918 : 175) in N. America and Panama. The species preys on large Short-horned Grasshoppers which she stores, one at a time, in cells at the end of a short burrow.

Isodontia Patton.

6. *I. costipennis* (Spinola, 1851).

I have examined the following specimens from British Guiana:—♂♀ (*Rodway*); ♂♀ N.W. District, Issororo (G. E. Bodkin); ♀ Essequibo R., Moraballi Creek, dark forest, 4 Sept. '29 (O.U. Exped.).

The insects of this genus always prey on Long-horned Grasshoppers and close the entrance of the nest with vegetable matter, often pieces of grass. The nest is apparently always in a ready-made cavity. Bristowe (1925 : 383) has published some notes on the habits of the present species in Brazil. A female wasp was seen depositing a Long-horned Grasshopper in a hollow bamboo. This was split open and found to contain three lots (*i.e.* cells) of grasshoppers, 7, 8 and 4 (the last probably incomplete) respectively. The groups were separated by wads of pappus and chewed vegetable matter. The wasp was closely mimicked by an Asilid fly, *Plesiomma fuliginosa* Wied.

Mayer and Schulthess (1923) describe the nests of this species brought back by Herr Zürcher from Paraguay. It is not recorded where the nests were situated, but they consisted of long cylindrical bags (5–8 × 1.5–2.5 cm.) woven of hairs from Apocynaceae or Asclepiadaceae. The cell inside one bag contained four or five nymphs of *Plenina* sp. (TETTIGONIIDAE) and the cocoon of the wasp, a male of which emerged. *Chalcis* sp. emerged as a parasite.

In the British Museum is a nest of this species, the actual example mentioned by Smith (1859) as probably belonging to *Sphex lanieri*. Fortunately,

however, a male of *I. costipennis* bred from the nest still exists in the Museum collection. This nest is in a large curled-up leaf of which the tip is somewhat incurved at the bottom, partially closing the cylindrical cavity. The cigar-shaped object so formed is about 14×2.5 cm. The cavity had been filled from above with a dense packing of plant wool, almost certainly the pappus of a plant. On pulling the wool out, it was found that most of the wool in the top 4 cm. was closely wrapped round an empty cocoon; there was almost certainly another cocoon lower down, but this part of the nest was not disturbed. The small fragments of prey remaining were most probably those of a Tettigoniid.

The cocoon was cigar-shaped, rounded at both ends, 20×5 mm. The outer covering was of white, semi-transparent, wrinkled silk. Inside this was a light brown layer of smooth, parchment-like material.

A full account of the recorded habits of the species of this genus will be found in a remarkable paper by Piel (1933).

7. *Isodontia bastiniana* sp. n.

Allied to *I. nigrocoerulea* (Taschenberg, 1869) but the third antennal segment is longer than the fourth, which is as long as the fifth; the antennal segments, also, are without warts.

♂. Agrees in every particular with Kohl's description of *S. (I.) nigrocoerulea* (see Kohl, 1890 : 38) except:—Clypeus and legs, except trochanters beneath, entirely dark. Antennae with segment 3 very distinctly longer than 6, 4–6 subequal, no flagellar segment keeled beneath nor covered with warts (i.e. minute bristle-bearing tubercles). Fore femora flattened and somewhat concave posteriorly. Abdominal sternite 1 with a few long black bristles; sternites 2–5 with a little fine white tomentum and a few scattered, outstanding, black bristles, no rows of dense, outstanding, pale hairs; sternite 6 with a few short, outstanding, pale hairs; sternite 7 weakly emarginate with short, outstanding, reddish-brown hairs; sternite 8 deeply, subcircularly emarginate with dense, outstanding reddish-brown hairs. Length 18 mm.

Type, ♂, BRITISH GUIANA, B.M. 1902–324 (purchased from Mr. Bastin).

Isodontia bipunctata described by Rohwer (1913) from Peru is stated to be black-haired, while the head and thorax have punctures of two sizes. In *I. bastiniana*, the hairs are white and only the bristles are black and the head and thorax are uniformly punctured.

Sphex Linnaeus.

8. *S. proximus* Smith, 1856, ♀.

(— ♂ *S. ruficaudus* Taschenberg, 1869).

I have examined the type of Smith's species, a female from "Brazil," and also the following specimens from British Guiana:—♂ N.W. District, Issororo, June '16 (C. B. Williams); 2 ♂♂ Mazaruni R., Kartabo, Aug. '22 (M. D. Haviland).

9. *S. funestus* Kohl, 1890.

This species was partly described from British Guiana (Demerara) and there is a female captured by Rodney in the collection of the British Museum.

10. *S. flavipes* Smith, 1856 var. *iheringi* Kohl, 1890.

I have examined one female from British Guiana :—Ituni Savannah, Cattle Trail Survey, May '19 (A. A. Abrahams).

11. *S. caliginosus* Erichson, 1848.

(= *S. erythroptera* Cameron, 1888).

A female from British Guiana from the Cameron collection is preserved in the British Museum. The museum also possesses a female, Tobago, Sept. '13 (*G. H. Sworder*), which is accompanied by its prey—*Idiarthron* sp. (TETTIGONIIDAE) (det. B. P. Uvarov).

12. *S. latro* Erichson, 1848.

(= *S. roratus* Kohl, 1890).

Dr. H. Bischoff has kindly examined Erichson's type and has established the above synonymy. Erichson's species was collected on the savannah of British Guiana by Schomburgk.

13. *S. fuliginosus* Dahlbom, 1843.

(= *S. congener* Kohl, 1890).

I have examined the following specimens from British Guiana :—♀ (*Rodway*); ♀ Essequibo R., Potaro, June '08 (*S. M. Klages*). Dr. H. Bischoff has kindly confirmed the synonymy by examination of the types.

14. *S. neotropicus* Kohl, 1890.

I have examined two females of this species from British Guiana :—Essequibo R., Moraballi Creek, 1 Nov. '29; Cuyuni R., Kamaria landing, 25 Nov. '29 (O.U. Exped.). Both were captured in camp clearings.

Howes (1919 : 68) gives what purports to be an account of the behaviour of this species in British Guiana. But there must be some confusion in his notes, since he describes the species as building mud-cells and preying on spiders.

15. *S. brasiliensis* Saussure, 1867 var. *tinctipennis* Cameron, 1888.

I have examined the following specimens of this species from British Guiana :—Essequibo R., Moraballi Creek, ♀ on trail 17 Sept. '29, ♀ burrowing near trail 24 Sept. '29 (O.U. Exped.).

The last-named specimen was heard buzzing as it jammed earth into the mouth of its burrow. The latter had been made in a very small patch of exposed sand amongst the dead leaves about four feet from the edge of a trail in dark forest. The significance of the buzzing of burrowing Sphecoids, which so often leads to the detection of insects which would otherwise be passed unnoticed, has been discussed by C. B. Williams (1921). It is probably only a necessary accompaniment of strenuous exercise. The burrow of the present female was about half an inch in diameter and went three inches downwards and then three horizontally. The end-cell contained five Long-horned Grasshoppers, of which four were immature. Some were still able to move their antennae.

16. *S. ichneumoneus* (L., 1758) var. *sumptuosus* Costa, 1862.

This species was recorded from British Guiana by Kohl (1890 : 432). I have examined the following specimens :—♀ Essequibo R., Monkey Jump, dark forest 9 Oct. '29 (O.U. Exped.); 2 ♀♀ 1 ♂ (near this variety) (Rodway).

Bodkin (1917) studied the species (presumably in the above variety) in British Guiana. The prey consisted entirely of nymphs or short-winged adults of grasshoppers. Poulton (1917) has recorded several observations on the prey of this species at São Paulo, S.E. Brazil. They consisted entirely of Long-horned Grasshoppers. The typical form of *S. ichneumoneus* has been studied in some detail in the United States, by the Peckhams (1898 : 33) and others.

Sceliphron Klug.17. *S. fistulare* (Dahlbom, 1843).

This species is common on the coastal plain of British Guiana. I have examined one female—Georgetown, Botanic Gardens, Aug. '29 (O.U. Exped.). Bodkin (1917) has described its habits, which resemble those of other species of the genus. It makes mud-cells, attached to palings, houses, etc., and fills them with spiders.

Dynatus Lepeletier.18. *D. nigripes* (Westwood, 1832).

(= *ingens* (Smith, 1847); ♂ = *crassipes* Cameron, 1912).

This species was recorded from British Guiana by Kohl (1902 : 32), and the type of Cameron's species, described from British Guiana, is preserved in the British Museum. I have also examined a female from British Guiana in the Cameron coll.

This is one of the largest of all known Sphecooids (length about 55–60 mm.). It might be expected to prey on large cockroaches, but Smith (1847) suggests that it preys on spiders, probably owing to confusion with large species of *Pepsis*. Like some species of *Podium*, it probably builds nests in, or on, wood. It would be very difficult otherwise to explain its introduction to Constantinople recorded by Fahringer (1921).

Podium Fabricius.

The species of this genus are mostly rare in collections, probably because they frequent forest rather than clearings and cultivated land (see remarks under *Trigonopsis*, p. 107).

19. *P. rufipes* Fabricius, 1805.

(= *P. biguttatum* (Taschenberg, 1869)).

Howes (1919 : 33) observed the habits of this species in British Guiana, at Kartabo. He found that it makes mud-cells attached to houses and stores them with cockroaches, four to a cell. Similar observations have been made by F. X. Williams (1928 : 127).

20. *P. angustifrons* Kohl, 1902.

I have examined one female from British Guiana :—Essequibo R., Mora-balli Creek, on trail 27 Sept. '29 (O.U. Exped.).

21. *P. fumigatum* (Perty, 1833) var. *aurosericum* Kohl, 1902.

I have examined one female of this species from British Guiana:—Essequibo R., Moraballi Creek, in swamp 25 Aug. '29 (O.U. Exped.).

Kohl (1902 : 58) has already recorded the species from "Guyana." F. X. Williams (1928 : 127) observed what was probably this species at Tena, Ecuador. It was gathering mud on a trail and is presumably a mud-dauber.

22. *P. denticulatum* Smith, 1856.

(= *P. brevicolle* Kohl, 1902; = *Trigonopsis longipilosum* Cameron, 1912).

Besides Smith's and Cameron's types, I have examined several more females from Cameron's collection from British Guiana. F. X. Williams (1928 : 127) found it gathering mud on the trail at Tena, Ecuador, together with the previous species, and Rau (1933 : 103) found the present species under similar conditions in Panama.

23. *P. goryanum* Lepeletier, 1845.

(= *P. foeniforme* Cameron, 1912 nec (Perty)).

I have examined a British Guiana female from the Cameron collection. Williams (1928 : 127) found it at Blairmont, British Guiana, and notes that it is a rare, sylvan species. Another female in the British Museum collection bears the following data:—"Blairmont, 17 Aug. '24, taken in the act of inserting a roach into a disused *Passalus* hole in a decaying stump of *Hora crepitans*."

24. *P. mocsaryi* Kohl, 1902.

I have examined one female from British Guiana:—Essequibo R., Moraballi Creek, gathering mud from trail 17 Sept. '29 (O.U. Exped.).

25. *P. luteipenne* (Fabricius, 1805).

(= *flavipenne* Lepeletier, 1825, and Kohl, 1902).

I have examined three females from British Guiana:—2 (*Rodway*) and 1 (Cameron coll.). F. X. Williams (1928 : 118) observed its habits in some detail at Blairmont. It makes burrows in the soil and stores up cockroaches, apparently in this locality always the nymphs of *Epilampra abdomen-nigrum* Degeer. An analysis of 153 cells showed that 40 contained 1 roach, 66—2, 33—3, 10—4, 4—5. The species is a partial mud-builder, since the burrows are plugged with a stopper of moistened earth.

It is still too early to classify the species of the genus *Podium* according to their biology. It may be noted that Kohl (1902 : 10), if *Dynatus* and *Trigonopsis* which I regard as separate genera are excluded, recognises five structural groups of *Podium*. The biology of some members of four groups is partly known, viz. *Parapodium* (*P. rufipes* = *biguttatum*) mud-dauber; group of *P. fumigatum* (*P. angustifrons*, *P. denticulatum* (= *brevicolle*), *P. fumigatum*) mud-gatherers, probably either daubers or cavity-users; group of *P. goryanum* (*P. goryanum*, *P. mocsaryi*) cavity-users, second species, however, only seen gathering mud; group of *P. luteipenne* (= *flavipenne*) (*P. luteipenne*, *P. dubium* Tasch. and *P. haematogastrum* Spin.) all burrowers. (The habits of the last two species are described by F. X. Williams (1928 : 124; 126).)

Trigonopsis Perty.

The species of this genus appear to be essentially forest-insects which are only rather rarely seen on the coastal plains or along the edges of rivers. Consequently they are rare in collections, and the Oxford University Expedition had an unusual opportunity to study them, being stationed throughout in forest areas. The number of specimens in the British Museum collection was almost doubled by the addition of the Expedition material.

Trigonopsis appears to be definitely "adapted" to forest life; the nests are made on tree-trunks or on leaves of trees, the latter habit being almost unique amongst Sphecoidea (known also in some S. American species of *Trypoxylon*). The wasps sometimes even obtain water for nest-building from the axils of Aroids (see p. 110), though they have to descend to the ground to obtain mud for their nests and probably for their prey (cockroaches). The extraordinary triangular head, with a long, narrow neck behind the eyes, recalls the similar structure of some of the tree-haunting South American CARABIDAE (a group to which in general the habitat might be thought to be equally unsuited).

I have taken the present opportunity to make notes on all the species of the genus, since certain species described by F. Smith have not been recognised by other authors. Species not yet recorded from British Guiana are unnumbered in the text.

26. *T. affinis* Smith, 1851.

I have examined the following specimens of this species:—Brazil, ♀ type, Para; ♂ São Paulo: British Guiana, ♀ Essequibo R., Moraballi Creek (O.U. Exped.).

The species has also been recorded from British Guiana by Kohl (1902 : 36) and by F. X. Williams (1928 : 115) from Ecuador. The specimen obtained by the O.U. Exped. is a variety in which the three central clypeal teeth are larger than the lateral ones and the fore femora are black.

T. cyclocephalus Smith, 1873.

I have examined the following specimens of this species: Brazil, ♂ type, Ega; ♂ Villa Nova: Bolivia, ♀ (J. Steinbach).

The association of the Bolivian female with the males is necessarily very problematical until more material is available.

27. *T. intermedius* Saussure, 1867.

(*affinis* Kohl, *nec* Smith).

The following specimens have been examined:—British Guiana, ♀ (A. W. Barlett), ♀ (J. Rodney), ♂ (Cameron coll.), ♀ Essequibo R., Moraballi Creek, 29 Aug. '29 (O.U. Exped.), ♀ same locality 22 Oct. '29 (O.U. Exped.). The last-mentioned specimen was carrying a cockroach up a hollow in a Mora tree. It may, perhaps, be suspected that the species is one that nests on tree-trunks.

28. *Trigonopsis moraballi* sp. n.

♀. Black; mandibles except the tips, and scape of antennae beneath, yellowish. Palpi reddish. Dorsal streak of fore tibiae, fore tarsi, and dorsal streak of mid tibiae, reddish. Abdomen, except petiole, reddish. Wings hyaline with dark bands across basal vein

(*mcu*₁) and across radial and third cubital and end of second discal cells. Pubescence silvery, short and dense on lower part of face, on proepisternum and fore coxae; forming bright silvery patches along posterior margin of pronotum, at mesopleural spiracle, at anterior end of mesosternum, along postero-ventral margin of mesopleuron, across post-scutellum and base of propodeum and on propodeum above each hind coxa. Length 20 mm. *Clypeus* with two strong triangular teeth between which lie four small but sharp ones. Part of head between the eyes about as long as the greatest distance between them. Pronotum smooth and shining, raised into a strong tubercle just before its posterior margin. Mesonotum smooth and shining with fine, very sparse punctures, disc weakly depressed. Mesopleuron shining with sparse, fine punctures. Furrow dividing off dorsal sclerite of mesepisternum moderately strong, but only weakly crenate. Lateral depressions of scutellum crossed by three strong keels. Metapleuron shining, sparsely punctured above, smooth below, ventral furrow separating it from metasternum rather weak, crenate. Pterostigma apically truncate. Dorsal surface of propodeum with a weak central keel situated in a furrow, dorsal surface strongly and regularly striate. Abdominal petiole one and a half times as long as dorsal furrow of propodeum, cylindrical, a little broader posteriorly, in lateral view nearly straight.

♂. Resembles the female except in the following particulars:—L. 18 mm. Orbita with a narrow yellow spot at level of clypeus. Fore tarsi dark. Clypeus with two strong teeth separated by a U-shaped emargination; teeth with their outer edges subparallel, distance between their tips only half the distance from the tip to the nearest point of the eye; distance from tip of tooth to bottom of emargination between them much less than that from bottom of emargination to level of lower edge of antennal sockets. Lateral depressions of scutellum crossed by only two keels. Abdominal petiole relatively a little longer. Abdominal sternites 4–6 with dense, modified tomentum. Abdominal sternite 7 triangular, strongly keeled.

Type, ♀, BRITISH GUIANA: Essequibo R., Moraballi Creek, bred nest underside palm-leaf, 2 Sept. '29 (O.U. Exped.). Allotype, ♂, same locality, 13 Aug. '29 (O.U. Exped.). Paratypes, all from same locality, ♀ from same nest as type; ♀ nest on leaf of sapling, 3 Oct. '29; ♂ bred nest on leaf in clearing, 20 Sept. '29; further ♂ Brazil (B.M. coll.). The paratype, ♀, from the same nest as the type and the paratype captured on 3 Oct. '29, differ from the type in having a large, pale yellow spot on the inner orbit at level of the clypeus.

The following are some notes on the biology of the species.

Nest 1, found by Mr. N. Y. Sandwith on the underside of a leaf four feet from ground, 20 Sept. '29. There were two mud cells in contact, with their long axes parallel; size, outside 20 × 10 mm., inside 17 × 7 mm. The cells lay with one of their long sides attached to the leaf and with one end at the mid-vein. In one cell was a single, rather large wingless cockroach. It was distinctly alive and still capable of moving its legs and antennae. The egg of the wasp was white, slightly curved, 3 × $\frac{3}{4}$ mm. long, attached to the mesosternum, just under the fore legs. The other cell contained three smaller cockroaches. Of the wasp larvae, one died and the other pupated on 29 Sept. and emerged during the journey home in October.

Nest 2, found by Mr. J. E. Duffield on the underside of a leaf of a sapling about six feet from the ground, 3 Oct. A single mud-cell, about 35 × 12 mm., was still open at one end. The cell broke on removing it from the tree and the prey were lost; there were two of them, almost certainly cockroaches. The wasp carried its prey with the aid of her mouth and fore legs.

Nest 3, found beneath a palm leaf, 2 Sept. It consisted of three cells and

produced two female wasps and one Bombyliid fly, *Anthrax leucopyga* Macquart ♂ (det. Dr. F. W. Edwards).

29. *T. violaceus* Smith, 1851.

(♀ = *resplendens* Kohl, 1902).

I have examined the following specimens of this species:—type ♂ Brazil, Para; ♀ British Guiana, Essequibo R., Moraballi Creek, dark forest, 6 Nov. '29 (O.U. Exped.). Richards (1935) records the breeding of a parasite, *Pachyophthalmus floridensis* subsp. *antillarum* Rich., from a mud nest of this species in Trinidad, by Mr. D. Vesey Fitzgerald.

T. cameronii Kohl, 1902.

(= *violaceus* Cameron nec Smith).

Kohl regarded this form as a variety of *T. abdominalis* Perty, but I think it must be given at least subspecific rank. I have examined the following specimens:—♀ Guatemala, Vera Paz, San Juan (Champion); ♀ Mexico, Tabasco, Teapa March (H. H. Smith); ♀ "Cananche" July. Kohl records it (1902 : 39) from Panama, Colombia and French Guiana. The male appears to be unknown. F. X. Williams reared the species (1928 : 115) from a mud-cell nest found at Bucay, Ecuador.

30. *T. abdominalis* Perty, 1833.

(? = *rufiventris* (Fabricius, 1805)).

I have examined the following specimens of this species:—Brazil. 2 ♀♀ Para; 2 ♂♂ Villa Nova; ♂ São Paulo: British Guiana. ♀ (Brit. Mus. coll.); 5 ♀♀ 1 ♂ from one nest, Essequibo R., Moraballi Creek, 21 Aug. '29; ♀ same locality, 6 Sept. '29; ♀ from nest in same locality, 7 Sept. '29 (O.U. Exped.).

The following are some notes on the biology of the species. F. X. Williams (1928 : 115) published observations on the nesting-habits of an Ecuadorian wasp which he identified as this species. He noted, however, that it differed in certain particulars from specimens captured in Guiana. In view of the possibility that an undescribed allied species might well exist, I cannot refer his observations here with complete confidence. Both the nests he found were on the underside of palm-leaves, whereas the nests I found in Guiana were on trees.

Personal observations. Nest 1. Found at Moraballi Creek on the branch of a tree about four feet from the ground, 21 Aug. '29. There were six cells, 25 × 8 mm., lying side by side with their mouths upwards. While they were still being filled, the mouths of the cells have a definite rim and the outside of the cells still showed the individual pellets from which it had been built. The nest had four closed cells and two open ones. The nest was removed and later two wasps were found searching the site. One was without prey, the other carried a small adult cockroach in its mouth; the prey was carried in the wasp's mouth head foremost, upside down. Possibly the combined cell-mass may have belonged to two individuals. Prey taken from the unclosed cells still showed movements of the legs and antennae in the evening. The closed cells produced a male and three females in about three weeks' time.

Nest 2. The nest was found in the same locality on 7 Sept. '29, under the thick overhanging roots of an uprooted tree, about four feet from the ground.

It consisted of one cell finished and closed, two finished but open, and one in the course of construction. The earth was obtained from amongst the tree-roots just above the nest. Every two or three minutes the wasp flew off to get water, either drops from the surface of leaves or from the axils of the leaves of the Aroid, *Philodendron rudgeanum* Schott. (det. Mr. N. Y. Sandwith), which was climbing over the tree. The cell was built from above downwards, the rim or collar being constructed first. The wasp worked upside down, putting her head through the collar and building from the inside. The walls were made of a number of small pellets, placed side by side. On 8 Sept. there were two cells closed and three open. The nest was now accidentally destroyed by one of the other entomologists, who captured the wasp.

31. *Trigonopsis gryloctonus* sp. n.

♂. Black; mandibles pitchy; palpi, underside of scape and a minute linear spot on inner orbit at level of clypeus, yellowish. Femora with violet reflections, knees reddish. Abdomen, except petiole, reddish. Wings hyaline with dark bands across the basal nerve and across the radial, second cubital and second discal cells. Pubescence silvery, forming bright patches at the mesopleural spiracle, the lower posterior corner of the mesopleuron, the top of the metapleuron, on a transverse band across the anterior margin of the propodeum and on a patch on the propodeum above the hind coxae. Length 12 mm. *Clypeus* with two strong apical teeth, separated by a U-shaped emargination. Part of head between the eyes one and a third times longer than the greatest distance between them. Pronotum smooth and shining, not raised into a tubercle posteriorly. Mesonotum raised on each side of the depressed disc, shining with large, very sparse punctures. Mesopleuron shining, almost unpunctured, furrow separating the upper from the lower part of the mesepisternum weak, unpunctured. The single keel crossing the depressions on each side of the scutellum very weak. End of pterostigma truncate. Metapleuron smooth, unpunctured, crossed by a keel which is a continuation of the strong posterior mesosternal border, but ventrally to this only separated from the metasternum by a weak, weakly crenate furrow. Dorsal surface of the propodeum with a central furrow which is crossed by regular transverse keels; longitudinal keel down centre of furrow (dividing two rows of punctures) only indicated. Dorsal surface smooth and shining with sparse scattered punctures, only punctate-striate laterally and posteriorly. Abdominal petiole moderately long, about one and two-thirds times as long as dorsal furrow of propodeum, thickened in centre and thinner at each end, a little longer than the remainder of the abdomen, in lateral view little curved. Apex of sternite 7 rather deeply and subangularly excised, with a patch of dense pubescence on each side. Sternite 8 triangular, apex with a small patch of dense short outstanding pale pubescence, narrowly emarginate.

Type, ♂, BRITISH GUIANA: Essequibo R., Moraballi Creek, nest on leaf of tree 25 Sept. '29 (wasp emerging later) (O.U. Exped.).

The following characters will separate this species from *T. abdominalis* :—

T. abdominalis. Larger, length 17 mm. Apex of pterostigma not truncate. Furrow separating off top of mesepisternum strong, strongly crenate. Metapleuron with quite a number of large punctures and also, where it passes between mid and hind coxae, completely divided from metasternum by a strong crenate furrow. Petiole long and narrow, fully twice as long as dorsal furrow of propodeum, considerably longer than the rest of the abdomen, parallel-sided, almost exactly cylindrical. Prey BLATTIDAE.

T. gryloctonus. Smaller, length 12 mm. Apex of pterostigma truncate. Furrow separating off top of mesepisternum weak, not crenate. Metapleuron unpunctured and

also, where it passes between the mid and hind coxae, not completely divided from the metasternum by a furrow, the incomplete furrow being only weakly crenate. Petiole shorter, distinctly shorter than twice the length of the dorsal furrow of the propodeum, hardly longer than the remainder of the abdomen, in dorsal view thicker at one-third its length from base than at either base or apex, in lateral view distinctly thickened just before its middle. Prey GRYLLIDAE.

In the preliminary sorting of material, this specimen was put down as a small specimen of *T. abdominalis*, but when the biological notes were examined, it was found that the prey in the nest was crickets. Later a number of small structural distinctions were noticed in the wasp.

The nest was found by Mr. N. Y. Sandwith on the underside of a leaf, attached to the mid-rib near the base. It was an ovoid mass of reddish mud, 30 × 20 mm. and 17 mm. deep (*i.e.* the cells had apparently been daubed over). One cell was still open; its internal diameter was 4 mm. and it contained a cricket. The type male emerged from the other cell in October, during the journey home.

The following key will assist in the separation of the species of *Trigonopsis*. One reputed species, *T. plesiosaurus* Smith, 1873, must be transferred to *Parapodium*. I have examined the unique type female, described from Ega, Brazil. The part of the head behind the eyes is much shorter than in *Trigonopsis* and there is no defined dorsal area to the propodeum. It is especially distinct in that the part of the head between the eyes is more than twice as long as broad.

Trigonopsis.

1. Prothorax posteriorly raised into an angular hump. Occipital keel forming a low collar. Scutellar depressions crossed by two or three keels. Dorsal surface of propodeum more or less distinctly striate 2.
- Prothorax posteriorly not angularly humped. Dorsal area of propodeum smooth or punctate, scarcely striate 9.
2. Females 3.
- Males 6.
3. Small species. Clypeus with very large, parallel teeth, with three others one-quarter their size between them. Head beneath flat, occipital hollow very small, occipital keel ventrally fading out gradually. Sixth sternite strongly keeled. Clypeus largely yellow, antennae pale beneath, fore legs red. *T. affinis* Smith.
- Resembles *T. affinis*, but three central clypeal teeth larger, and fore femora black *T. affinis* (variety from British Guiana).
- Large species. Head beneath not flat but occupied by a rather large occipital hollow. Sixth sternite not keeled. Female clypeus different. 4.
4. Clypeus with four strong teeth and a weak central one. Occipital keel strongly raised at the points where it ends ventrally. Clypeus largely pale, antennae black, mid and fore legs largely red. *T. cyclocephalus* Smith (?).
- Clypeus with a different arrangement of teeth. Occipital keel fading out gradually where it ends ventrally. Clypeus black, antennae black, scape pale beneath, legs black, fore tibiae and tarsi red-tinged 5.
5. Clypeus with two very strong diverging teeth, the margin between them irregularly serrate, forming 4-6 weak teeth. Supra-antennal keel distinct. Larger, propodeum dorsally more closely and strongly trans-striate *T. intermedium* Saussure.

- Clypeus with two very strong parallel teeth with four small sharp ones between them. Supra-antennal keel obsolete or nearly *T. moraballi* sp. n.
- 6. Clypeus black, if a little reddish, then the tips of the teeth extensively black. Antennae black, scape pale beneath. Four front tibiae and fore tarsi reddish. (Outer margin of clypeal teeth little convergent, no small tooth outside them.) 7.
- Clypeus considerably pale, at least the teeth entirely reddish. (Outer margins of teeth considerably converging.) 8.
- 7. Larger; emargination of clypeus very broad and deep. Distance between tips of teeth about as great as that between one of them and nearest point of eye. Tooth longer than distance from bottom central emargination to lower edge of antennal socket. Base of teeth reddish. Propodeal striae stronger *T. intermedius* Saussure.
- Smaller; emargination of clypeus smaller and narrower. Distance between tips of teeth much less than that from one of them to nearest point of eye. Tooth shorter than distance from bottom of central emargination to lower edge of antennal socket. Teeth black. Propodeal striae weaker *T. moraballi* sp. n.
- 8. Outer margin of clypeal teeth basally emarginate, leaving a small tooth just lateral to each big one. Clypeus and teeth entirely pale yellowish. Antennae black, scape pale beneath. Four front tibiae and tarsi pitchy. Clypeal teeth and emargination almost as large as in *T. intermedius*. Small species *T. affinis* Smith.
- No additional small teeth outside the big ones. Clypeus apically and the teeth reddish. Clypeal teeth and emargination more as in *T. moraballi*. Four front legs mainly and first three segments of antennae (except dorsal side of third) red *T. cyclocephalus* Smith.
- 9. Abdominal petiole rather strongly curved upwards near its posterior end. Prothorax definitely convex in profile, sinking abruptly posteriorly though not angular. Sides of propodeum striate. Violaceous species with underside of scape pale.
 ♀ mandible and narrow apical band to clypeus pale yellow (or Trinidad specimen) clypeus violet. Clypeus with five teeth, central one small, outer ones not very large.
 ♂ mandibles pitchy, clypeus black. Clypeus very strongly triangularly produced, production truncate *T. violaceus* Smith.
- Abdominal petiole nearly straight. Propodeum in profile almost quite flat. Clypeal teeth stronger and more of one size 10.
- 10. Violaceous species. Striae of sides of propodeum more irregular and effaced. Legs entirely dark. Clypeus apically pale *T. cameronii* Kohl ♀.
- Black species with red abdomen (except petiole). Striae of sides of propodeum stronger.
 ♀ four front knees pale; clypeus apically pale.
 ♂ four front legs largely red; clypeus usually black, rarely apically reddish, produced into a pair of strong teeth separated by a U-shaped emargination 11.
- 11. Larger, length 17 mm. or more. Petiole cylindrical, longer, twice as long as dorsal furrow of propodeum *T. abdominalis* Perty.
- Smaller, length 12 mm. Petiole thickened in middle, shorter.
T. grylloctonus sp. n. ♂.

BEMBECIDAE.

Parker (1929) has recently revised the species of this family and few taxonomic problems arise.

Rubrica Parker, 1929 (= *Monedula* auctt., in part).

1. *R. surinamensis* (Degeer, 1778).

I have examined the following specimens from British Guiana:—1 ♂ 5 ♀♀ Demerara, Mahaica, 15 Oct. '16. Parker (1929 : 55) also records the species from Georgetown.

Notes on the biology have been published by Poulton (1917), Lindner (1929) and Brèthes (1902). Lindner records that the Asilid, *Mallophora vegeta* Arribalz., preys on *R. surinamensis* in the Gran Chaco. Poulton records that the wasp preys on various Diptera at S. Paulo. Brèthes records that the species lives in rather numerous colonies on bare slopes and paths near Buenos Aires. The burrow is 10–12 cm. deep and leads to a horizontal cell, $1\frac{1}{2} \times 4$ cm. In absence the entrance is always closed. The prey is Diptera belonging to many families, including STRATIOMYIDAE, TABANIDAE, BOMBYLIIDAE, NEMESTRINIDAE, ASILIDAE, SYRPHIDAE, TACHINIDAE and MUSCIDAE. The egg is laid on a moderate-sized prey, on the wing near the calyptera. The larva spins a date-shaped cocoon of earth and silk with a fine silk lining. The head end is rounded and the other one pointed and there is always a small protuberance near the middle. Its dimensions are 1×3 cm.

The male recorded above from Mahaica emerged from a cocoon which is brown, stiff, parchment-like, cigar-shaped, narrowed at each end; dimensions 8 × 30 mm.

Engel (1936) records that Lindner bred the Bombyliid, *Hyperalonia morio* (Fabr.) from a nest of *R. surinamensis* in the Gran Chaco.

Stictia Illiger, 1807 (= *Monedula* auctt. in part).

2. *S. signata* (Linnaeus, 1758).

I have examined the following specimens from British Guiana:—3 ♀♀ Essequibo R., Moraballi Creek, 30 Aug. '29, 16 Sept. '29, 28 Sept. '29; Essequibo R. first falls, 2 ♀♀ 10 Sept. '29, 2 ♀♀ 14 Oct. '29; ♀ Essequibo R., Monkey Jump, 27 Oct. '29; ♀ R. Essequibo, river bank, 15 Nov. '29; Cuyuni R., Kamaria Landing, 3 ♀♀ 22 Nov. '29, 1 ♀ 23 Nov. '29 (O.U. Exped.); ♂♀ Mazaruni R., Nov. '16 (Bodkin); 2 ♂♂ Demerara. Parker (1929 : 27) records it also from British Guiana (9 April '01).

Bates (1876 : 182) found *S. signata* nesting on the banks of the Upper Amazons. It preyed on Tabanids, including *Lepidostelaga* (*Hadrus*) *lepidota*, sometimes catching them on the observer. The prey were tightly held against the underside of the thorax by means of the fore and mid feet. Bates describes the orientation-flight of the wasp when memorising its nesting-site. Neiva and Penna (1916 : 114) also record Tabanids as prey in Brazil.

Howard, Dyar and Knab (1912 : 171) record an interesting observation on the use of mosquitoes as food by the adults of this wasp. At Calapatch Is., near Cuba, Mr. H. J. Browne found the adults eating yellow-fever mosquitoes almost exclusively; they were seized and devoured on the wing. One wasp was seen to eat twenty in five minutes. This observation is, perhaps, unique; several fossorial wasps (e.g. *Mellinus*) are known to eat part of their prey, but the large-scale catching of prey of a special type unsuited to storage for the larva is not recorded elsewhere.

In British Guiana, *S. signata* appears to be essentially a river-bank species, nesting in sands which are submerged in the wet season. Such was its nesting-site at the first falls of the Essequibo R., where it was abundant on

small sandy islands in the middle of the river. At Moraballi Creek, where a moderately large clearing was made for camping, the wasps arrived and started nesting after about three weeks. On 12 Sept., two females were seen burrowing on a small sandy patch. They quarrelled a good deal with one another and one female several times investigated the other's nest. They were very shy of observation, especially of any movement by the observer. The burrows were initially horizontal, about half an inch in diameter. On the following day, one of the wasps was seen to return to its nest in the afternoon. In its absence, the entrance had become covered by dead leaves. Small pieces of leaf and root were lifted and carried several feet in the air and dropped. A larger leaf was dragged aside. One leaf was deeply embedded in the sand and could not be moved. The female attempted to burrow under one side of it, but she appeared very uneasy. She repeatedly flew two or three inches into the air to reorientate and made repeated attempts to drag the leaf away, but it broke in her jaws. Rain now began and she flew almost at once high into the air, probably to shelter in a tree. On 16 Sept., one of the wasps was caught with prey, a Muscoid fly. This was held so tightly against the underside of the thorax that it was hardly visible. When the nest was completed, the female filled it in with sand, which was rammed down with the tip of the abdomen (cf. Carpenter, 1930 : 300).

On several occasions small flies were seen standing near the burrowing females of *S. signata*. The flies were often perched on some projecting stick giving a good view of the burrow and they returned if they were frightened away. One female was identified as *Oscinella columbiana* End. by Dr. O. Duda. It is probable that this fly lays its eggs amongst the prey of the wasp, though such habits have not previously been recorded in the genus.

3. *S. pantherina* (Handlirsch, 1890).

I have examined one British Guiana female of this species—Demerara (Harper), Cameron coll.

4. *S. maculata* (Fabricius, 1805).

There is some difficulty in separating this species from *S. andrei* Handl. Parker tabulates them as follows:—

Scutellum lacking pubescence, very finely punctured with a few scattered larger punctures; labrum yellow; discal stripes on the scutum narrow. *andrei*
 Scutellum pubescent (at least at sides), uniformly and rather coarsely punctate; labrum with black central stripe; discal stripes on scutum broad. *maculata*.

In my opinion the presence or absence of short black pubescence on the scutellum is the best diagnostic character. In the material I have examined (all females, except two males of *S. maculata*), the two species work out as follows:—*maculata* (7 ♀♀) has pubescence on the scutellum, a black mark on the labrum (except for one specimen) and all the tarsi distinctly annulated with black. *andrei* (5 ♀♀) has no pubescence on the scutellum, the labrum yellow and the tarsi entirely yellow.

S. andrei has hitherto been recorded only from Peru (Handlirsch described 3 ♂♂, 21 ♀♀, while Parker saw 2 ♀♀). When defined as above, *S. andrei* seems to be nearly as common in British Guiana as *S. maculata*. I have seen the following specimens of *S. maculata* from British Guiana:—1 ♀ (Rodway)

(almost no black mark on clypeus); 2 ♀♀ Moraballi 23.ix.29; ♀ Moraballi 18.viii.29; ♀ Moraballi 24.ix.29; ♀ Moraballi, Wallaba Bush, 7.xi.29; ♀ Cuyuni R. Kamaria landing 25.xi.29.

Habits not known.

5. *S. andrei* (Handlirsch, 1890).

Besides one female from Peru, Nauta (det. Handlirsch), I have examined the following females from British Guiana:—♀ R. Mazaruni Nov. '16 (G. E. Bodkin); ♀ Monkey Jump 9.x.29; ♀ 1 m. N. of Monkey Jump 14.x.29; ♀ Moraballi 14.xi.29; ♀ Moraballi 15.xi.29.

Bicyrtes Lepeletier, 1845 (= *Bembidula* Burmeister, 1874).

6. *B. discisa* (Taschenberg, 1870).

I have examined the following specimens of this wasp from British Guiana:—2 ♀♀ (Rodway); ♀ Mazaruni R. (G. E. Bodkin); Essequibo R., Moraballi Creek, ♂ 9 Sept., ♀♀ 1 Sept., 5 Sept., 9 Sept., 17 Sept.; Essequibo R., Monkey Jump, ♀ nesting in sand, 11 Oct. '29 (O.U. Exped.).

All the specimens were captured in small clearings, where the sun could get at the soil and the solitary nests were always in sand (three observed). The female was twice caught with prey (9 Sept., 17 Sept.), in both cases an immature Pentatomid nymph. Brèthes (1918) found *B. discisa* nesting in a bank at the edge of a sandy path near Buenos Aires. The burrow consisted of a short oblique gallery at an angle of 45°, 10 cm. long, followed by a horizontal portion leading to a cell. The prey were nymphs of *Edessa meditabunda* L. (PENTATOMIDAE) and *Spartocerus brevicornis* Stål and *Pachylis argentinus* Berg. (COREIDAE).

7. *B. odontophora* (Handlirsch, 1889).

I have examined the following specimens of this species from British Guiana:—Essequibo R., Moraballi Creek, ♂ 12 Sept. '29; Monkey Jump, ♂♀ 7 Oct. '29, ♀ 14 Oct. '29 (O.U. Exped.).

8. *B. variegata* (Olivier, 1789).

(= *Bembex guyana* Cameron, 1912).

I have examined the following specimens of this wasp from British Guiana:—♀ (type of *guyana* Cameron); ♀ (Rodway); Essequibo R., Monkey Jump, 2 ♀♀ 7 Oct. '29 (O.U. Exped.). Parker (1929: 174) records it from Essequibo R., Bartica. Poulton (1917) notes that the prey in Brazil is immature Pentatomids. Claude-Joseph (1928: 119) has described the habits in greater detail in Chile, where it also nests in sand on the edge of rivers. A number of cells lie at the end of short galleries leading from a central burrow, the cells nearer the surface probably being made first. The cells actually lie between 1-2 and 10-15 cm. below the surface. The nest is closed by the sand during the wasp's absence. The prey all belonged to the large bug, *Leptoglossus (Anisoscelis) chilensis* Spin. (COREIDAE), both adults and nymphs.

Microbembex Patton, 1879.

9. *M. sulphurea* (Spinola, 1853).

I have examined the following British Guiana specimen of this species:—♀ Mazaruni R., Penal Settlement, 13 Sept. '16 (Bodkin).

Claude-Joseph (1928 : 113) and (1929 : 418) has described its habits in Chile. It nests in sand, making a short gallery at the end of which are several cells. The entrance of the nest is closed while the female is foraging. The prey is extremely varied, including *Galeodes* (Arachnid), beetles, Diptera, Homoptera, dragonflies and Hymenoptera. Its predatory habits thus resemble those of the well-studied *M. monodonta* (Say) which gathers dead insects or fragments of insects of all kinds from the surface of the soil. Claude-Joseph suggests that the prey are paralysed in the ordinary way, but it is, perhaps, more probable that they are collected dead as in *M. monodonta*.

The males of *M. sulphurea* spend the night in small burrows in the sand.

Bembecinus Costa, 1859.

10. *B. cingulatus* (Smith, 1856).

(= *Larra agilis* Smith, 1873; = *Bembidula ornaticauda* Cameron, 1912).

I have examined the following British Guiana specimens of this species (besides Smith's two types):—♀ (Cameron coll.; type of *ornaticauda*); 6 ♀♀ Essequibo R., Moraballi Creek, 9 Sept., 11 Sept., 3 12 Sept., 13 Sept., 21 Sept., '29 (O.U. Exped.); 8 ♀♀ Essequibo R., Monkey Jump, 2 7 Oct., 8 Oct., 2 9 Oct., 10 Oct., 2 14 Oct., '29 (O.U. Exped.).

The females of this species were rather common at Moraballi Creek, nesting in small patches of exposed sand in the camp clearing. A short burrow was constructed, leading to a cell a little way below the surface. The nest examined in detail consisted of one cell only, but possibly, if not interfered with, additional ones would have been constructed. While the female is away hunting, the entrance of the burrow is filled in with sand. The prey consist of JASSIDAE, either nymphs or adults. A female with prey was caught in the net, where she dropped her victim. They were put together in a glass tube. After struggling to escape for a time, she seized the prey, dorsal side uppermost and heads in the same direction, bent her abdomen round and stung it on the underside of the thorax. She then walked for a time carrying the prey in the same position, held by her mid legs. Specimens carrying prey to their nests, however, carry them upside down with the heads in the same direction. A female was seen filling in her burrow, carrying sand to it and pressing it down with her abdomen. This burrow was excavated and was found to contain two mature and two immature leaf-hoppers (*Ponama* sp.) and a wasp-larva three millimetres long. This suggests that the larva is fed after it has hatched, as in *Bembix*.

These observations suggest that the habits of *B. cingulatus* are extremely similar to those of the type-species of the genus, the European *B. tridens* (Fabricius), as described by Ferton (1908 : 554). In that species, also, progressive provisioning is recorded.

The following Homoptera were found as prey of *B. cingulatus* at Moraballi Creek:—*Cicadella* sp. 1 ♀ 3 nymphs; *Oncometopia* sp. 4 nymphs; *Dichrophleps* sp.; *Ponama* sp. 1 ♀ and 1 nymph; *Homalodisca* sp. 1 ♀. In the case of the nymphs the generic position is only approximate. The determinations are due to the kindness of Mr. W. E. China. In the British Museum collection there is further a female of *B. cingulatus* from Panama—Almirante, 7 Feb. '17 (C. B. Williams)—with its prey, *Ponama* sp. ♂ (det. W. E. China).

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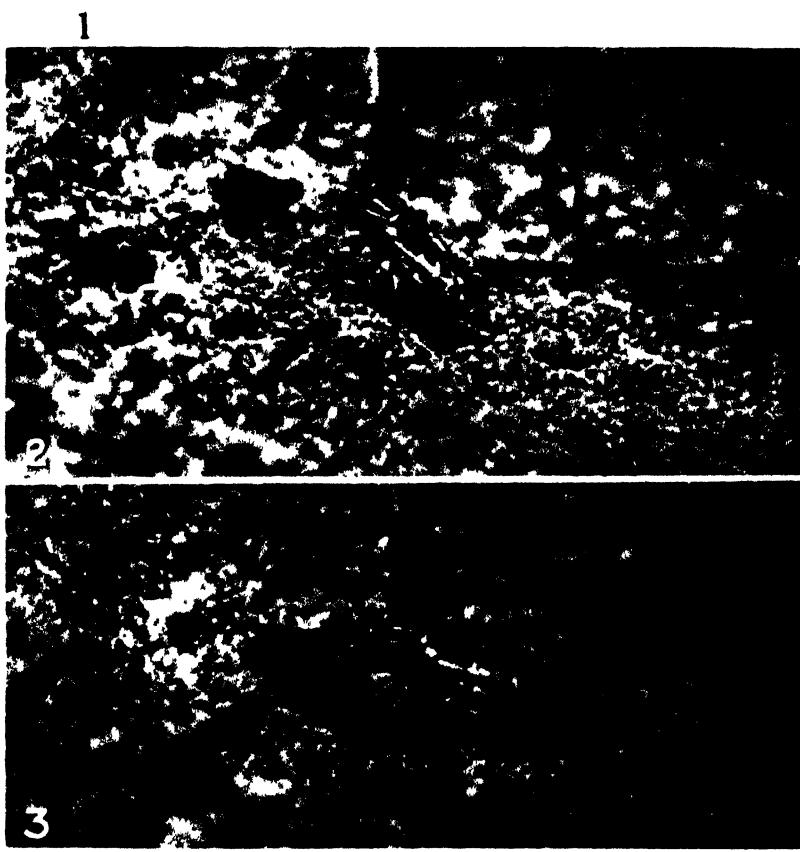
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PLATE 1.

FIG. 1. Two-cell nest of *Trigonopsis moraballi* Richards. The surface which was attached to a leaf has been photographed. (Photo. J. E. Duffield.)

FIGS. 2-3. Two views of the female of *Stictia signata* (L.) at the entrance to her nest. (Photo. J. E. Duffield.)



OBSERVATIONS ON THE COCCIDAE OF SOUTHERN RHODESIA.*

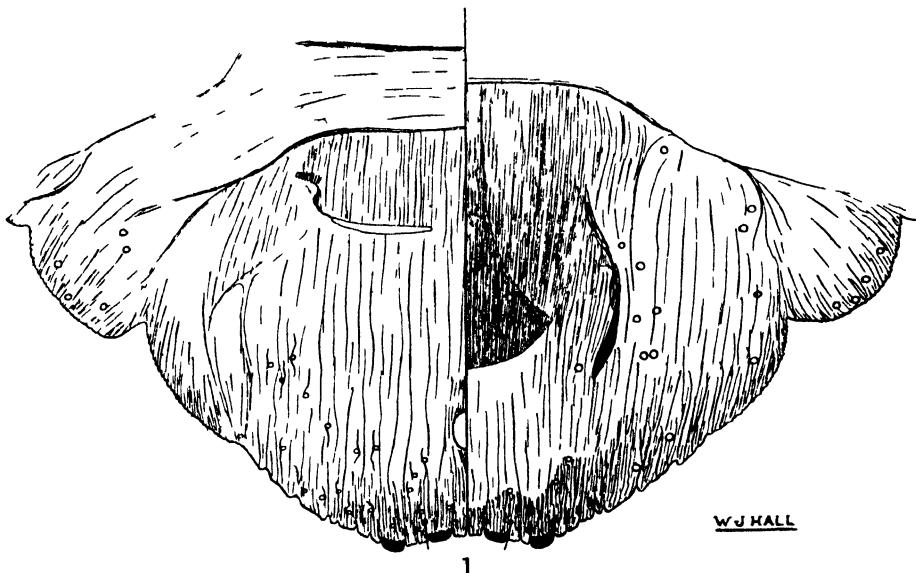
By W. J. HALL, D.Sc.

(Mazoe, Southern Rhodesia.)

[Read 18th November, 1936.]

***Furcaspis cynodontis* sp. n. (fig. 1).**

Puparium of the adult female more or less circular in outline, convex and black. Larval exuviae pale straw-coloured and overlaid by a film of white secretory matter. Nymphal exuviae very dark brown and to a greater or lesser degree obscured by a black secretory film. Exuviae not quite central. Secretory area black with minute but distinct concentric growth lines. Ventral scale entire with a dirty white roughly circular area

FIG. 1.—*Furcaspis cynodontis* sp. n. : Pygidium of adult ♀, $\times 340$.

situated towards one side; there is a dorsiventral slit of the margin on the opposite side. Remainder of ventral scale black with faint concentric growth lines. The puparia often split dorsiventrally and the ventral scale remaining adherent to the host-plant is readily seen on account of the conspicuous white area.

Diameter of female puparium, 1.0-1.25 mm.

Adult female broadly oval but tapering posteriorly. Antennae represented by minute tubercles carrying one long and one short seta. No parastigmatic glands associated with either anterior or posterior spiracles but the dermis surrounding them, more particularly

* Seven parts of this series have already appeared as follows:—*Bull. ent. Res.*, 1928 and 1929; *Trans. ent. Soc. Lond.*, 1931; *Stylops*, 1932 and 1935.

the anterior pair, exhibits a roughly reticulated ornamentation. Abdominal segmentation not clearly defined. Margin of abdominal and thoracic segments with only a very few minute tubular spinnerets and in the frontal region there are a few very short setae at widely separated intervals.

Pygidium broadly rounded but flattened and somewhat recessed at the apex. Only two pairs of lobes are apparent; these are subequal, short, squat and not very conspicuous. The median pair of lobes are separated by two plates which are rectangular in shape with the flattened apex sometimes appearing notched. Two similar plates occur between the median lobes and the 1st lateral lobes on either side, and beyond the latter there are usually three more but these are sometimes not very obvious. Arising from the outer base of each median lobe is a short seta. Anal orifice situated towards the apex of the pygidium. Circumgenital glands wanting. Dorsal dermis in the vicinity of the margin with a few scattered minute tubular pores; ventral dermis with a few similarly scattered pores of a slightly larger size. The entire dermis of the insect has singularly few pores and these only of a very inconspicuous nature.

On *Cynodon dactylon* (Gramineae)—rhizomes. From my garden at Mazoe, 15.vii.34.

The white boss on the dorsal scale enables this species to be readily detected and the ventral scale is equally conspicuous, when the dorsal scale has been knocked off, on account of the circular white area. There are only two pairs of pygidial lobes, whereas in the genus *Furcaspis* there are said to be more than three pairs. Neither the lobes nor the plates are conspicuous in this species, but the plates do seem to be of the form characteristic of the genus *Furcaspis*, and for that reason it has been assigned tentatively to that genus.

Aulacaspis pentagona Targ.

Diaspis pentagona, Targ., 1885, *Rev. di Bacch.*, No. 11.

" *amygdali*, Green, 1896, *Coccidae of Ceylon*, 1 : 87.

" *pentagona*, Newstead, 1901, *Mon. Brit. Cocc.*, 1 : 173.

Aulacaspis pentagona, Brain, 1919, *Coccidae of South Africa*, *Bull. ent. Res.*, 9 : 194.

On *Allamanda grandiflora* (Apocynaceae), Umtali, 9.iv.35, coll. M. C. Mossop, ex coll. Dept. Agric. Salisbury, No. 4243.

The material is typical of this widely distributed species. It appears to be common on a number of nursery plants in the Union of South Africa (Brain, *loc. cit.*) and it is therefore somewhat surprising that this is the first occasion that it has been detected in this Colony.

Chionaspis (Dinaspis) pygaei sp. n. (fig. 2).

Puparium of the adult female relatively large, narrowed in front and broadening posteriorly; highly convex. Larval exuviae golden. Nymphal exuviae a reddish-brown covered by a thin film of dirty white secretory matter which obscures the colour but is readily peeled off. The exuviae occupy rather more than $\frac{1}{2}$ of the entire puparium. Secretory appendix a dirty white with rather unusually conspicuous transverse striations. Ventral scale white and thin, usually broken away to a greater or lesser degree over the posterior half.

Length of puparium of adult female, 2.5-3.0 mm.; breadth, 1.0-1.25 mm.

Adult female removed from its puparium large, globose and pyriform. Antennal tubercles with a small curved bristle. Anterior spiracles with a compact crescent-shaped group of some 13-20 parastigmatic glands; posterior spiracles without any such glands. Abdominal segmentation clearly discernible especially at the margin. Free abdominal

segments with numerous large oval pores with short tubular ducts and a scattered group of aciculate gland spines; the former are most numerous in the marginal extension of the segment and give way gradually to single row of pores running towards the median line but stopping about midway between the margin and the median line. Similar pores and gland spines also occur on the thoracic segments.

Pygidium large and flatly rounded. Median lobes small and separated widely by a shallow notch. The lobes are very variable in shape; usually they are somewhat longer than broad, rounded apically and with a faint notch generally in the vicinity of the outer angle. Examples have been seen in which the lobe is produced to a sharp point, whilst in others it is broader than long with a flattened and serrated apex. Forms intermediate between these three are common. First lateral lobes duplex, the inner lobule being larger

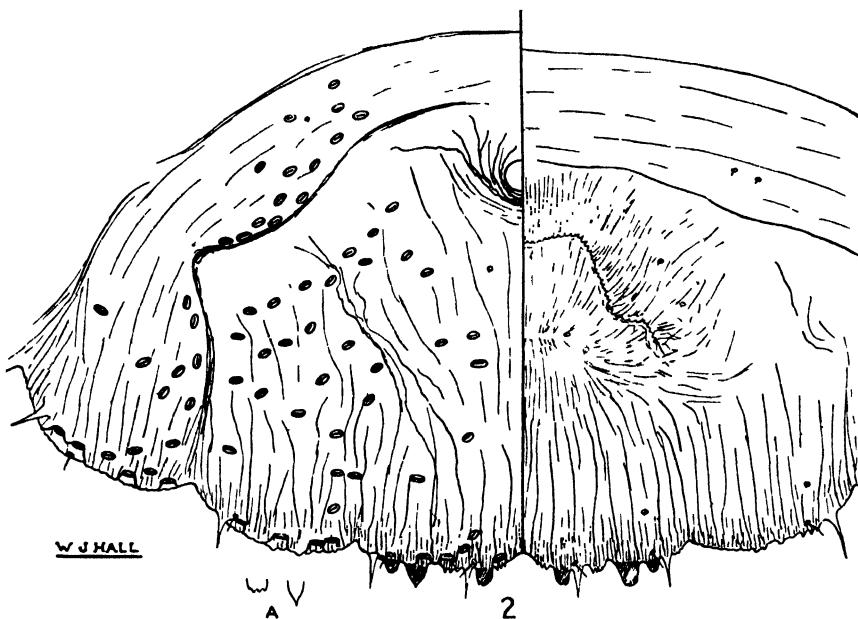


FIG. 2.—*Chionaspis (Dinaspis) pygaei* sp. n.: Pygidium of adult ♀, $\times 227$; A, alternate forms of the median lobes, $\times 227$.

than the outer and much the same size as the median lobe. The inner lobule is longer than broad and either pointed, broadly rounded, notched or somewhat flattened at the apex. The outer lobule is small and generally broadly rounded at the apex. The shape of the lobules does not show the great range of variation noted in the median pair, but the outer lobule varies in size from little short of that of the inner lobule to complete absence. Other lobes not apparent. The margin of the pygidium shows minute but sharp serrations; these are most obvious between the median lobes and between the median and lateral lobes. Anal orifice towards the base of the pygidium. Dorsal pores large and conspicuous, relatively numerous but with no obvious arrangement. Marginal pores similar in nature. Circumgenital glands wanting. In older individuals the dermis becomes somewhat chitinised.

On *Pygaeum africanum* (Rosaceae), Melsetter, July 1934, coll. R. W. Jack, ex coll. Dep. Agric. Salisbury, No. 3759. On the smaller twigs and leaves.

This species is quite distinct from any other species of *Dinaspis* collected

in the Colony, and it appears to be different from the species of this subgenus described by Newstead and Lindinger. Although the adult female is relatively large it is not easy to obtain satisfactory preparations on account of the comparative insignificance of the characters of the pygidial fringe. Early adult females are the most suitable for preparation.

Ceroplastes toddiae var. *spicatus* var. n. (fig. 3).

This variety differs from *C. toddiae* Hall (1931, *Trans. ent. Soc. Lond.*, 79 : 229) in the following respects :—

1. It is larger. The diameter of the test of the adult female is 8–10 mm., height, 7–8 mm.
2. Apex of test produced into a stout and conspicuous spike which is directed anteriorly.
3. The limbs are relatively a little larger.
4. The reticulate ornamentation of the dermis is hardly discernible, and the honey-combed areas noted in *toddiae* although present are less conspicuous.

On *Uapaca kirkiana* (Euphorbiaceae), South Marendellas, 21.x.35.

This is a striking species which, under the microscope, is practically indistinguishable from *toddiae*. It differs from that species in its larger size



FIG. 3.—*Ceroplastes toddiae* var. *spicatus* var. n., $\times 1.65$.

and the fact that the dome of the test instead of carrying a shallow median depression is produced into a stout and conspicuous spike. The radiating shaded effect on the dome so typical of *toddiae* is also present in this variety.

The specimen selected as the type is a young adult female.

Akermes andersoni Newst.

Newstead, 1917, *Bull. ent. Res.*, 7 : 347.

On leaves of Grape-fruit, Vumba, 24.iii.35, coll. M. C. Mossop. In this instance all the individuals were confined to the *upper* surface of the leaves, chiefly in the vicinity of the midrib. Further material from the same source collected in November 1935 showed that all the individuals were situated on the *under* surface of the leaves, again in the vicinity of the midrib. In both cases the leaves were heavily infested and exactly as described by Newstead. "completely covered with a rather dense, dusky white, mealy secretion, which also spreads over the surrounding portions of the food plant, giving the infested leaves an almost uniform mealy appearance."

Rhodesian examples agree very closely with Newstead's description and with specimens on *Citrus nobilis* from Uganda in my collection which are believed to be *A. andersoni*.

Newstead appears to have experienced difficulty in assigning this species to its proper generic position and he placed it provisionally in Cockerell's genus *Akermes*. In 1921 Green (*Ann. Mag. nat. Hist.* (9) 8 : 639) described a genus *Cribrolecanium* into which *andersoni* would seem to fit perfectly, and it may be that it should be transferred thence from its provisional home in *Akermes*.

Pulvinaria aristolochiae Newst.

Newstead, 1917, *Bull. ent. Res.*, 8 : 19.
Brain, 1920, *Cocc. South Africa*, V. *Bull. ent. Res.*, 11 : 260.
Hall, 1932, *Stylops*, 1 : 187.

One of the striking features of *aristolochiae* is the large size and conspicuous nature of the submarginal pores and pores of a similar nature found elsewhere on the dermis. Some material collected on *Uapaca kirkiana* (Euphorbiaceae) at South Marendellas in October 1935, whilst indistinguishable from *aristolochiae* in all other respects, exhibited uniformly small submarginal and dermal pores, strikingly smaller than those found in typical *aristolochiae*. It was thought at first that this was a well-defined variety, but subsequently some material on *Anona reticularis* (Anonaceae) collected at Umtali in February 1934 was received from the Department of Agriculture, Salisbury, in which the submarginal pores were of the large typical form whereas those elsewhere on the dermis were of the small type found in the specimens from *Uapaca*. In the nature of the pores this material is intermediate between true *aristolochiae* and the material from *Uapaca*.

It is also to be noted that in *aristolochiae*, and in the other two lots of material above referred to, the dermal pores have associated with them small conical tubercles which are rounded at the apex. The number of these vary, sometimes they are entirely absent, but in most cases they are not only present but often form a complete circle around the pore at a little distance from it.

Tachardina affluens Brain.

Brain, 1920, *Cocc. South Africa*, *Bull. ent. Res.*, 10 : 125.
Chamberlin, 1923, *Bull. ent. Res.*, 14 : 206.
Hall, 1935, *Bull. ent. Res.*, 26 : 483.

On *Dodonaea* sp. (Sapindaceae), Bulawayo, January 1936, per A. Cuthbertson, Dept. of Agric. Salisbury. A *Dodonaea* hedge was said to be attacked and the material submitted consisted of sections of branches some three-quarters of an inch in diameter.

It is interesting that this species should have been collected in S. Rhodesia. In the preparation of a recent paper (*loc. cit.*) material of this species from the Union of South Africa was studied. The present individuals from Bulawayo agree in all respects with those from South Africa.

Eriococcus araucariae Mask.

Maskell, 1879, *Trans. N.Z. Inst.*, 11 : 218.
Brain, 1915, *Trans. Roy. Soc. S. Africa*, 2 : 85.
Green, 1922, *Cocc. of Ceylon*, 5 : 348.

On *Araucaria* sp. (Araucariaceae), Municipal Park, Umtali, 9.vi.28.

Rhodesian specimens are typical of the species and identical with those from other countries in my collection.

Eriococcus rusapiensis sp. n. (fig. 4).

Early adult female ovate, dark maroon in colour and liberally covered with long slender setae. Later the adult female becomes enclosed in a closely felted sac which is either dirty white or straw-coloured. The sac has a small opening at the caudal extremity through which protrude the anal lobes.

Male puparium small, elongate oval and closely felted; of a similar colour and appearance to that of the female but smaller and of a different shape.

Length of test of adult female, 2.0-2.5 mm.; breadth, 1.0-1.5 mm.

Adult female with usually seven segments to the antennae but in some examples there

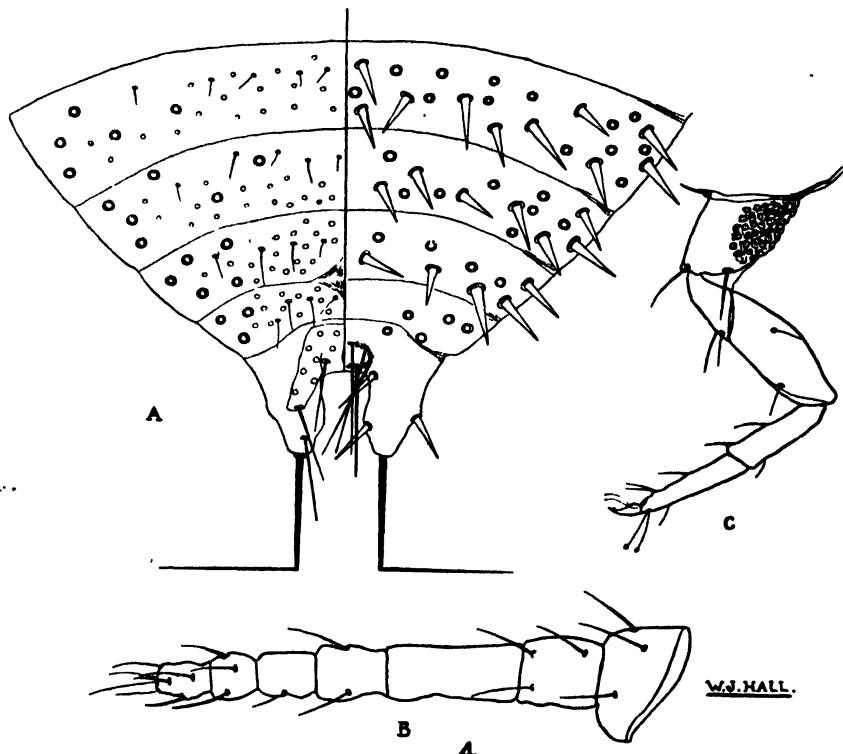


FIG. 4.—*Eriococcus rusapiensis* sp. n. : Adult ♀. A, posterior extremity of abdomen, $\times 114$; B, antenna, $\times 227$; C, hind limb, $\times 114$.

are only six owing to the absence of any division between the 3rd and 4th segments. In the normal 7-segmented antenna the 3rd segment is much the longest, the 2nd is the next longest, being only very slightly longer than the 4th and rather more than half as long as the 3rd. The 5th, 7th, and 6th are successively slightly shorter. There are no setae on the 3rd segment.

Legs comparatively short. Coxae of hind limbs relatively large with a honeycomb effect on the outer surface which is apparently due to irregularly circular depressions. It is not quite clear whether these are of a glandular nature as their structure is somewhat obscure, but there is some evidence to believe that they may be. They are much larger and of an entirely different nature from the usual type of translucent pores found on the hind coxae of certain species of *Pseudococcus*. Femora short and stout. The combined length of the femur and trochanter is slightly less than that of the tibia and tarsus. Tarsus a little

longer than the tibia. Claw with a minute subapical denticule; both pairs of digitules slender and faintly knobbed, the tarsal digitules being longer and more noticeably knobbed than the ungual pair.

Dorsal dermis liberally covered with conspicuous stout sharply-pointed spines of varying sizes; they do not occur in the intersegmental region and consequently they appear to be arranged in bands. Interspersed amongst the spines are a number of large circular pores.

Ventral dermis with numerous minute, apparently multilocular, pores particularly on the posterior abdominal segments. Towards the margin these are gradually replaced by a few circular pores of the large type found on the dorsum. Each segment with a transverse series of small slender setae.

Anal lobes of normal type. The caudal setae slightly more than twice as long as those of the anal ring. The anal lobes in addition carry three or four stout spines.

On *Achyropsis* sp. (Amarantaceae), Rusapi, 2.x.32; attacking the roots.

This species is undoubtedly closely allied to *Eriococcus kijabensis* James described from Kenya Colony (1934, *Stylops*, 3 : 270). Through the courtesy of Dr. James it has been possible to examine two slides of *kijabensis* and it is noted that, whilst the dermal characters show a striking similarity, the antennae and limbs are quite different. In *kijabensis* the antennae are 7- sometimes 8-segmented with the 4th segment somewhat longer than the 3rd; the limbs are much longer and more slender with the tarsus shorter than the tibia and not exhibiting any of the curious honeycombed effect on the coxae. It is clear, then, that, whilst the two species are closely allied, they must be regarded as distinct.

Halimococcus lampas Ckll.

Cockerell, 1902, *Entomologist*, 35 : 15.

Brain, 1920, *Cocc. of South Africa, Bull. ent. Res.*, 10 : 126.

Stickney, 1934, The External Anatomy of the Red Date Scale, *Phoenicococcus marlatti* Cockerell, and its allies. *U.S. Dept. Agric. Tech. Bull.*, 404 : 79.

On *Hyphaene* sp. (Palmae), Victoria Falls, 31.vii.29.

This species was originally described by Cockerell from Natal and no record has been seen of its occurrence outside the Union of South Africa. It has recently been redescribed, also from South African material, by Stickney (*loc. cit.*) in great detail. There can be no doubt that the Rhodesian material is referable to this species.

Antonina indica var. *panica* Hall.*

Hall, 1925, *Min. Agric. Egypt. Tech. Sci. Serv. Bull.*, 64 : 6.

On *Eragrostis* sp. near *chalcantha* (Gramineae), Theydon, 17.iii.28; attacking the roots.

This species was described from *Panicum turgidum* growing in the Egyptian desert, it is therefore somewhat surprising that it should turn up in S. Rhodesia under such very different conditions. Individuals from Rhodesia are almost

* I owe a debt of gratitude to Dr. T. J. Naude, Chief Entomologist of the Department of Agriculture, Pretoria, for the loan of representative slides of all the available Pseudo-coccine species from the collections of his Department, and to Mr. H. K. Munro, Collection Entomologist in the same Department for the great trouble they have gone to in this connection. The study of the Rhodesian material has consequently been much simplified, and any possibility of describing species as new which have previously been described from the Union of South Africa has been avoided. It is a matter for surprise and regret that not more of the species described as new were not already known from the Union of South Africa.

identical with typical *panica*. The only differences detected are that the anal tube, whilst of much the same length, is somewhat narrower and the dermal pores appear to be slightly less numerous.

Pseudococcus burnerae Brain.

Brain, 1915, Cocc. of S. Africa, *Trans. Roy. Soc. S. Africa*, 2 : 47.

On *Beaumontia grandiflora* (Apocynaceae), Municipal Gardens, Salisbury, 3.xi.27, and Govt. Forest Nursery, Salisbury, 23.ix.32; on *Uapaca kirkiana* (Euphorbiaceae), the Kopje, Salisbury, 23.xi.27.

One paratype and three other slides of *P. burnerae* Brain have been available for examination. The host-plant in the first instance was "Grenadilla" and in the other three Foxglove, Oleander and *Sida longipes*. Rhodesian examples from Beaumontia are somewhat larger than the South African individuals and from Uapaca rather smaller, but there can be little doubt that they are all referable to Brain's species.

It may be of interest to mention one or two additional characters not referred to by Brain. Thirty-four ceriferous tracts are present and it is noticed that the first four tracts on either side often carry three spines, and in one or two instances four, instead of the normal two. Minute translucent pores are present on the coxae and distal half of the tibiae of the hind pair of limbs. The large circular discoid pores and small trilocular pores on the dermis are not very numerous. In addition there may be a few large circular pores with conspicuous subcutaneous tubes; when these are present they are usually to be found in the vicinity of the margin, and if represented at all one or two can readily be found in the frontal region. There are in addition some much smaller circular pores also with subcutaneous tubes. The anal setae vary from $\frac{1}{2}$ to $\frac{3}{4}$ the length of the caudal setae.

Pseudococcus citri Risso.

Dorthesia citri, Risso, 1813, *Essai Hist. nat. Orangers*.

Pseudococcus citri, Brain, 1915, Cocc. of S. Africa, *Trans. Roy. Soc. S. Africa*, 2 : 51.

" " Green, 1922, Cocc. of Ceylon, 5 : 375.

On *Citrus aurantium* (Rutaceae), Mazoe, 6.ii.28 and Sinoia, 15.xii.27; *Pavetta schumanniana* (Rubiaceae), Headlands, 29.xi.27; *Ficus* spp. (Moraceae), Mazoe, 18 and 21.xi.27, and on the roots of *Ficus* sp., Mazoe, 29.vi.28; *Anona senegalensis* (Anonaceae), Embeza, 11.iii.28; *Coffea* sp. (Rubiaceae), Glen Livet, Fort Victoria, June 1932, ex coll. Dept. Agric. Salisbury, No. 3145; *Mangifera indica* (Anacardiaceae), Mdanga, Jan. 1930, coll. T. J. Williams, ex coll. Dept. Agric. Salisbury, No. 2573.

This species is relatively common on *Citrus* but it is rarely present in sufficient numbers to cause any material damage. Rhodesian material is typical of this cosmopolitan species which appears to be widely distributed throughout the Colony. There is no doubt that it will be found to have a wide range of host-plants when further and more extensive collecting is undertaken.

Pseudococcus filamentosus Ckll.

Cockerell, 1893, *Entomologist*, 26 : 268.

Brain, 1915, Cocc. of S. Africa, *Trans. Roy. Soc. S. Africa*, 2 : 35.

On *Citrus aurantium* (Rutaceae), Mazoe, 10.xi.27; *Loranthus* sp. (Loranthaceae), El Dorado, 29.iii.28; *Vernonia glabra* (Compositae) Umtali, 20.iv.32 and on *Citrus* sp. Salisbury, Jan. 1936, per A. Cuthbertson, Dept. of Agriculture, Salisbury.

This species is another which is common on *Citrus* in the Colony, but up to the present it can hardly be regarded as a pest of any significance.

Pseudococcus longispinus Targ.

Targioni, 1869, Catalogue : 32.

Brain, 1915, Cocc. of S. Africa, *Trans. Roy. Soc. S. Africa*, 2 : 42, under *P. adonidum* (Linn.) Westw.

On "Fern," Avondale, 6.vii.28.

Rhodesian specimens are typical of this widely distributed species.

Pseudococcus mazoeensis sp. n. (fig. 5).

Adult female, globose, usually brown in colour but some individuals show a tinge of pink. It has a somewhat dense covering of white pulverulent matter which in old specimens has often been worn off to some extent. Marginal filaments confined to the abdominal region; they are short and stout increasing in size towards the caudal extremity but even the caudal pair are short. Adult female viviparous.

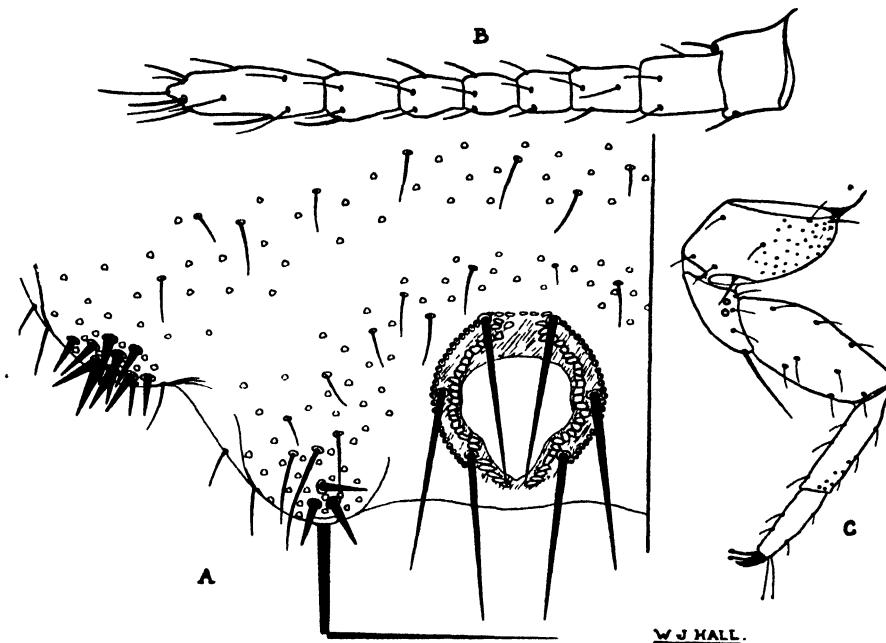


FIG. 5.—*Pseudococcus mazoeensis*, sp. n. : Adult ♀. A, dorsal aspect of posterior extremity of abdomen, $\times 227$; B, antenna, $\times 227$; C, hind limb, $\times 114$.

Length of adult female, 2-3 mm.; breadth, 1.5-2.5 mm.

Antennae of the adult female consisting of eight segments with the relative lengths of the various segments more or less constant. The terminal segment is much the longest and is nearly twice as long as the 1st and 2nd, which are subequal. The 7th, 3rd, 6th, 5th and 4th are successively shorter. In two examples the division between the 4th and 5th segments was incomplete.

Limbs relatively short and robust. The tarsi of the hind pair are about $\frac{1}{3}$ the length of the tibiae, whilst the tibiae are about $\frac{1}{4}$ the length of the femora. The coxae are comparatively large and carry a few scattered minute translucent pores on their outer surface;

the tibiae also carry a few similar pores at their distal extremity. The tarsal and unguial digitules normal, the latter being shorter and somewhat stouter than the former.

Mentum relatively large and sharply pointed. Anterior and posterior osteoles present.

Caudal setae long and stout (about 200μ in length). Anal setae approximately half the length of the caudal setae. Anal ring large and of normal type. Only five pairs of well-defined cerarii are present and these are confined to the posterior abdominal segments; they are situated on rounded tubercles. The anal cerarii consist of 2 to 5 stout spines (usually 3 or 4), 4 to 6 setae of varying lengths and a loose group of small trilocular pores. The cerarii of the penultimate and antepenultimate segments consist of 9-14 stout spines, 3-5 setae and a group of scattered pores. In the two groups anterior to these the spines are successively less (7-9 and 4-7). There may be one to four slender spines on the two segments anterior to these, but there are no definite cerarii; the spines in this case are a transition stage between the true cerarian spines and the stout setae which occur on the dermis.

Dermis with scattered small trilocular pores and several stout setae of varying lengths. Large circular discoid pores are confined to the ventral aspect of the posterior abdominal segments.

An oval or dumb-bell-shaped translucent area occurs medioventrally between the 2nd and 3rd abdominal segments.

On *Acacia* sp. (Leguminosae), Mazoe, 27.xii.27 and 24.ii.28; on *Zizyphus jujuba* (Rhamnaceae), Mazoe, 18.i.28 and 14.xii.31.

The nature of the cerarii should serve to enable this species to be readily distinguished. It seems to form a connecting link between *Pseudococcus* and *Tylococcus*, but it has been assigned to the former genus on account of the reduced number of cerarii and the fact that the marginal tubercles upon which these are situated are perhaps not so well developed as in typical *Tylococcus*.

Although it is apparently not uncommon in Rhodesia none of the species described or recorded by Brain from South Africa are comparable.

Pseudococcus nipae Mask.

Maskell, 1892, *Trans. N.Z. Inst.*, 25 : 230.

Brain, 1915, *Cocc. of S. Africa, Trans. Roy. Soc. S. Africa*, 2 : 38.

On *Chamaerops excelsa* (Palmae), Govt. Forest Nursery, Salisbury, 9.ix.32, and on an unknown host-plant, Salisbury, 26.xi.31.

Rhodesian individuals agree well with the description of this striking species and with a preparation from the Hawaiian Islands in my collection.

Pseudococcus proteae sp. n. (fig. 6).

A small ovate species in which the brownish colour is obscured by a coating of white pulverulent matter. Four short and stout caudal filaments; these are about $\frac{1}{2}$ of the length of the body of the insect. A few successively shorter marginal filaments occur on the abdominal segments, but these are poorly developed in some individuals. Ovisac of indeterminate shape. Eggs very pale brown almost yellow.

Length of the adult female, 2.0-2.5 mm.; breadth, 1.25-1.5 mm.

Adult female with relatively long and slender antennae of eight segments. The relative lengths of the various segments show some variation; figure 6b represents the average of 15 examples. The terminal segment is always much the longest, with the 2nd and 3rd next longest. As a rule the latter is the longer, but this is by no means invariably the case. The 5th and 7th are more or less of the same length and the next longest, whilst the 4th and 6th are subequal and the shortest, but there is a good deal of variation in the relative

lengths of these segments. The number and arrangement of setae on the segments is normal, but they are longer than usual. The terminal segment exhibits a pseudoarticulation in most examples.

Limbs relatively long and slender. In the hind pair the tibia is somewhat longer than the femur and about three times the length of the tarsus. No translucent pores present. Tarsal digitules normal, ungual pair thickened and distinctly knobbed.

Mentum comparatively long and sharply pointed. Anterior and posterior osteoles present but not very conspicuous.

Caudal setae long and stout (about 220μ in length). Anal setae about $\frac{3}{4}$ the length of the caudal pair. Anal ring of normal form. There are seven to nine pairs of ceriferous

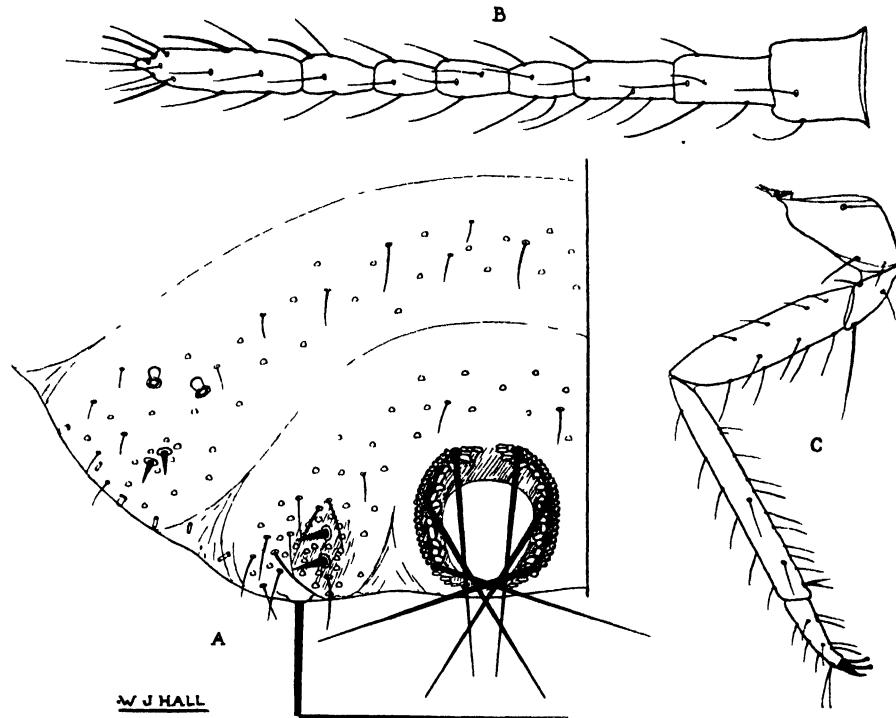


FIG. 6.—*Pseudococcus proteae* sp. n.: Adult ♀. A, dorsal aspect of posterior extremity of abdomen, $\times 227$; B, antenna, $\times 227$; C, hind limb, $\times 114$.

tracts present. The anal pair consist of two medium-sized spines surrounded by a loose group of minute trilocular pores. Several setae of varying lengths, mostly rather long, are associated with the group. The area surrounding the base of the spines is faintly chitinised. In the penultimate pair the spines are smaller and the trilocular pores much fewer; no setae appear to be directly associated with the tract. In the other cerarii the spines are small, getting smaller and more slender in the anterior groups and with only two or three trilocular pores. Traces of other cerarii can be seen in some examples, but not more than 7 to 9 pairs can be said to be definitely present.

Dermis with the usual trilocular pores which are most numerous on the dorsal dermis; the large circular discoid pores are confined to the ventral dermis and not very numerous. In addition, there are a few large circular pores with conspicuous subcutaneous tubes chiefly in the vicinity of the margin on the dorsal dermis. Similar pores of a smaller size are

moderately numerous on the ventral dermis. There are numerous scattered setae on the dermis of varying sizes, some of these are as much as 100μ in length.

On *Protea* sp. (Proteaceae), Inyazura, 20.iv.32. Found on the terminal shoots either on the main stem or on the under surface of the base of the leaf or petiole. In all cases they were enclosed within a thick-walled cell composed of matted earth and fibres and closely attended by ants.

This species is quite distinct from any recorded or described from South Africa by Brain. It has characters which distinguish it readily from any other species known to me.

***Pseudococcus rhodesiensis* sp. n. (fig. 7).**

Adult female ovate to elongate ovate and pale to bright yellow in colour. The segmentation is distinct and the dermis is sparsely dusted with a little white pulverulent matter. No marginal or caudal filaments apparent. Later the female becomes enclosed in a cell of white fibres of indeterminate shape, the inside of which is comparatively smooth and matted.

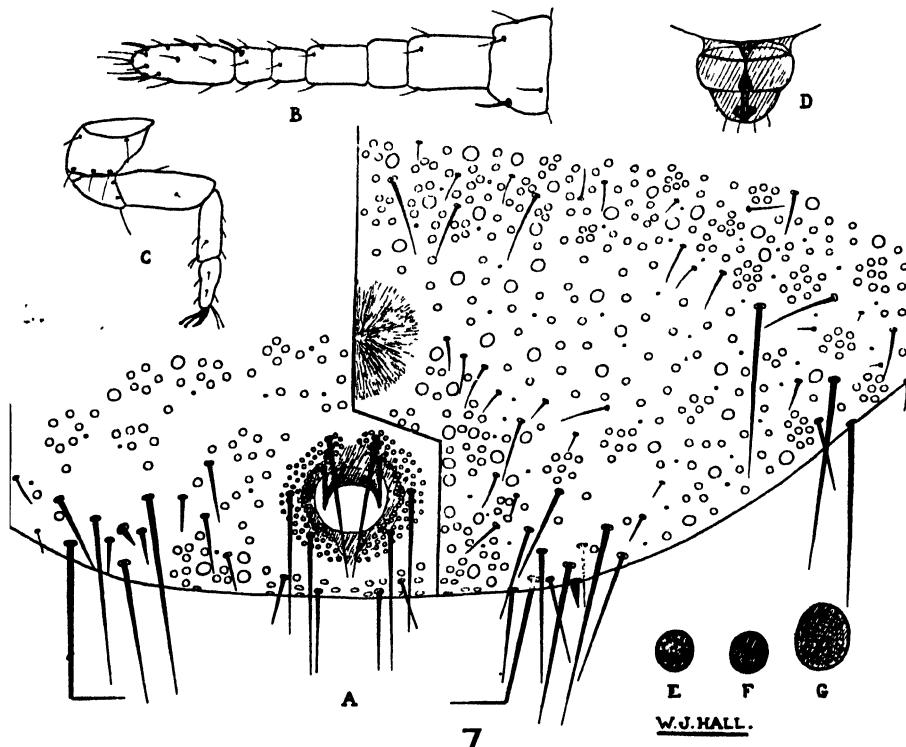


FIG. 7.—*Pseudococcus rhodesiensis* sp. n. : Adult ♀. A, posterior extremity of abdomen, $\times 170$; B, antenna, $\times 227$; C, hind limb, $\times 114$; D, mentum, $\times 114$; E, multilocular pore, F, pore with three crescent-shaped loculi, G, pseudocribiform plate, all $\times 1135$.

Greatest length of an adult female, 3.5 mm.; breadth, 2.4 mm.

Antennae of the adult female extremely variable. They are always short but they may have 6, 7 or 8 segments and the length may vary appreciably. The terminal segment is always the longest with the 3rd segment—in the 6-segmented antenna—very little shorter and the 2nd slightly shorter than the 3rd. In the 7-segmented antenna the 3rd segment is subdivided into two portions of which the distal is somewhat the longer. In the 8-seg-

mented antenna the distal portion apparently becomes further subdivided. The relative lengths of the segments also show variation. The setae on the various segments are much as usual but somewhat shorter.

The limbs are small. In the hind pair the tibiae are a little shorter than the femora and the tarsi than the tibiae. Setae on the limbs are scanty and short. There are no translucent pores. Ungual digitules normal, but the tarsal digitules are no longer than the ungual pair and they are not terminated by the usual small swelling.

Mentum very short and bluntly rounded.

There are no ceriferous tracts and the usual seta on each anal lobe is replaced by a group of stout setae of varying lengths, the longest of which is about 160μ in length. Associated with this group of setae is usually one, sometimes two, spines of the type normally found in the ceriferous tracts. There are no trilocular pores in the vicinity of the group of anal setae. At the margin of the penultimate segment a similar group of setae occurs; these are more scattered and less numerous but the longest attain much the same length as those of the caudal group. There are no definite spine groups anterior of the penultimate segment, but marginally of each segment there are a few long and stout setae which tend to become shorter on the anterior segments.

The anal ring has the usual six stout setae each of about 110μ in length. There is a tendency for the posterior pair of setae to be longer than the median pair and the median than the anterior pair, in one example there is a difference of 20μ in length between the anterior and posterior pair. The cells composing the inner ring are small and they are surrounded by a ring of small pores often three deep.

Dermis with two types of round discoid pores of approximately the same size. The one is of the multilocular type, whilst the other is divided into three crescent-shaped loculi. In the marginal area, except on the anal segment, the former occur in very distinct groups of often as many as 12 pores. On the anal and penultimate segments occur scattered, usually broadly oval, structures of varying sizes; these are generally larger than the other pores and not infrequently twice as large. Their structure is obscure, in some respects they resemble cribriform plates but they have not the regular nature of such structures. A few scattered very small pores with subcutaneous tubes occur, but the usual trilocular and large circular discoid pores are entirely absent. A few scattered rather stout setae occur all over the dermis. Anterior and posterior osteoles not apparent, but the genital orifice is conspicuous and associated with two pairs of long chitinous thickenings in the dermis.

On Grass roots, South Marendellas, 23.ii.36.

This is unlike any other species known to me. It has been placed in *Pseudococcus* provisionally although in certain respects it does not conform to the characters of that genus. The dermal glands and pseudocribriform plates are most unusual, whilst the nature of the anal lobes, anal ring and grouping of the dermal pores at once serve to distinguish it from other species.

Trionymus inyazurae sp. n. (fig. 8).

Adult female ovate, pale brown to maroon, but the colour is somewhat obscured by a very fine and uniform film of white pulverulent matter. Segmentation distinct. There are no marginal filaments, and in the absence of these the four very short caudal filaments are readily seen. Ovisac of indeterminate form but composed of fibres that are capable of being drawn out to a considerable length.

Eggs pale brown. Young adult females are relatively elongate filling out and becoming more ovate later.

Length of the adult female, 2.0–2.5 mm.; breadth, 1.25–1.75 mm.

Antennae of the adult female rather short and of eight segments. The terminal segment is much the longest with the 2nd slightly more than half its length; the 7th, 5th

and 6th are successively shorter than the 2nd, whilst the 3rd and 4th are the shortest, the latter usually being the longer of the two. The number, nature and arrangement of the setae on the various segments are normal.

Limbs inclined to be slender; the tibiae of the hind pair are very little shorter than the femora and about twice the length of the tarsi. Minute translucent pores relatively

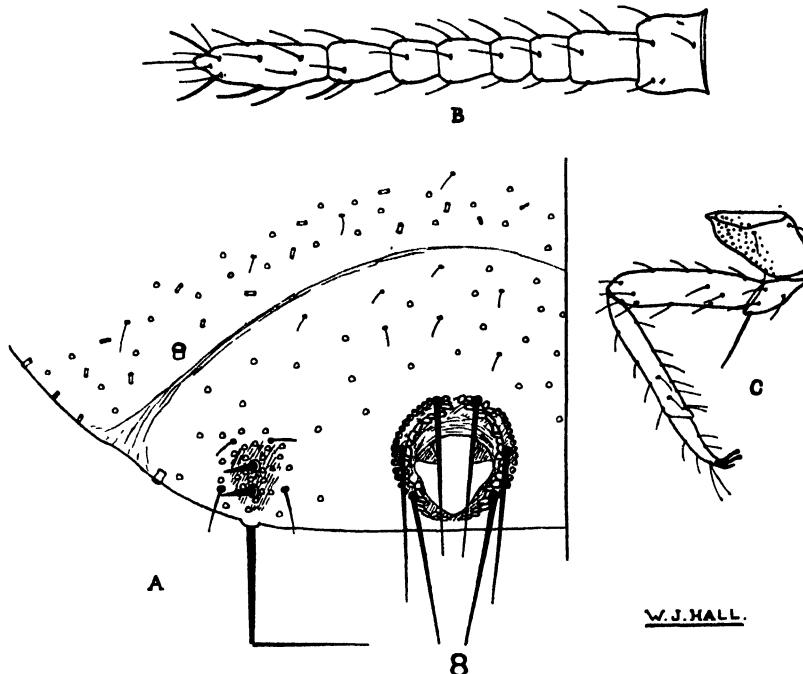


FIG. 8.—*Trionymus inyazurae* sp. n.: Adult ♀. A, dorsal aspect of posterior extremity of abdomen, $\times 227$; B, antenna, $\times 227$; C, hind limb, $\times 114$.

numerous on the outer surface of the coxae. Tarsal and ungual digitules present, the former are hair-like and very faintly knobbed, whilst the latter are stouter and more conspicuously knobbed.

Anterior and posterior osteoles present; these are small but can be readily detected.

Anal setae (90μ) about $\frac{2}{3}$ the length of the caudal setae. Anal ring of normal type.

Cerarrii confined to a pair on the caudal lobes. They consist of a pair of medium-sized spines surrounded by a loose group of small trilocular pores and usually four setae of varying lengths. The area around the base of the spines is faintly chitinised.

Dermal pores normal in number and arrangement. In addition to the usual small trilocular pores and large circular discoid pores there are a very few large circular pores with conspicuous subcutaneous tubes, more particularly in the marginal region. There are also similar pores of smaller and varying sizes scattered all over the dermis.

Dermal setae scattered, mostly short and not very numerous or conspicuous.

On Grass, Inyazura, 18.iv.32. The insects were found just underground at the base of the aerial shoots.

This species is quite distinct from any recorded or described by Brain from South Africa. *P. socialis* Brain described from grass has only the anal cerarrii represented, but the nature of the cerarrii and the antennae is quite different.

Trionymus masrensis Hall.Hall, 1925, *Min. Agric. Egypt. Tech. Sci. Serv. Bull.*, 64 : 10.

On Grass roots, Trelawney, 26.iii.28.

Rhodesian material is tentatively assigned to *T. masrensis*, which was described from the roots of a grass in Egypt. The material is not quite typical but the differences are so small that there is hardly sufficient justification to consider it distinct. The limbs and antennae tend to be relatively a little larger than in typical *masrensis* and the dermal pores to be rather more numerous.

Trionymus pterocauloni sp. n. (fig. 9).

Adult female small and pale brown, but the colour is obscured by a coating of white pulverulent matter. Segmentation distinct. Marginal filaments confined to two very short pairs at the caudal extremity. Many of the individuals were enclosed in small cells of matted white fibres.

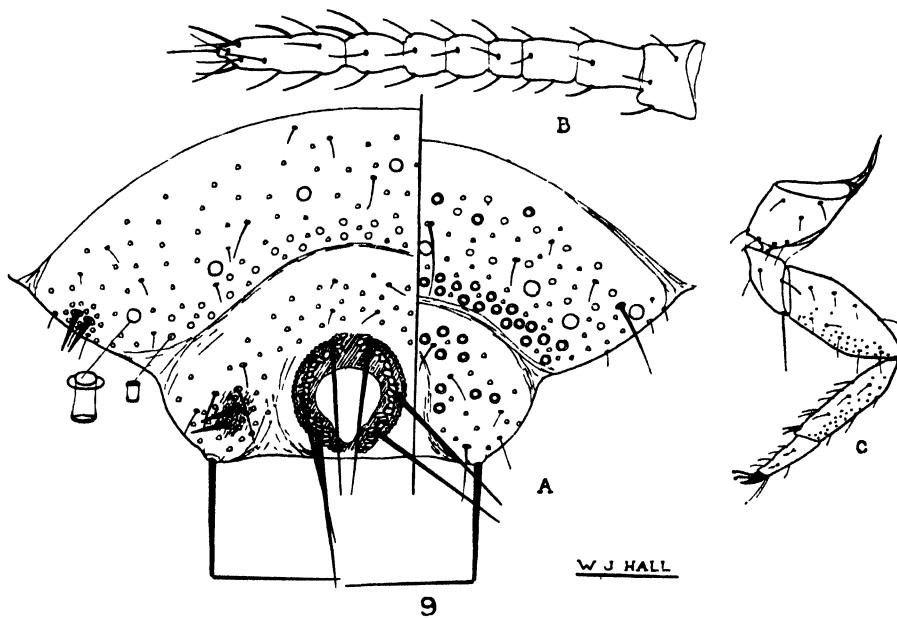


FIG. 9.—*Trionymus pterocauloni* sp. n. : Adult ♀. A, dorsal aspect of posterior extremity of abdomen, $\times 227$; B, antenna, $\times 227$; C, hind limb, $\times 114$.

Length of the adult female, 1.5-2.25 mm.; breadth, 1.0-1.5 mm.

Antennae of the adult female normally of eight segments. The 8th segment is much the longest, being rather more than twice the length of the 2nd, the 7th is shorter than the 2nd, and the 3rd than the 7th; the 5th and 6th are subequal and shorter than the 3rd, whilst the 4th is the shortest. There is a certain amount of variation in the relative lengths of the segments but it is not excessive. The number and nature of the setae on the various segments is normal.

In the material from *Pterocaulon* the antennae were uniformly of 8 segments whilst in that from *Trifolium* they were either of 7 or 8 segments, the division between the 4th and 5th being incomplete or absent. The antennae in the case of the latter host-plant are also somewhat shorter than in that of the former.

Limbs relatively rather small and stout. Tarsi of the hind pair about $\frac{1}{3}$ the length of the tibiae; femora very little longer than the tibiae. Minute translucent pores comparatively numerous on the inner surface of the femora and the outer surface of the tibiae. Digitules normal with the ungual pair shorter and slightly stronger than the tarsal pair.

Caudal setae about 140μ in length. Anal setae about 90μ . Anal ring of normal type.

Cerarii limited to two pairs on the caudal and penultimate segments. The caudal cerarii consist of two long and relatively rather slender spines surrounded by a loose group of small trilocular pores; the area around the base of the spines is faintly chitinised. Three or four setae of varying lengths are also associated with the group of pores surrounding the spines. The cerarii of the penultimate segment are much the same except that there are fewer pores and usually only two or three small setae.

Five distinct types of pores are to be found on the dermis:—

1. Small trilocular pores of the usual type; these are more numerous on the dorsal dermis.
2. Large circular discoid pores of normal form, most numerous on the ventral aspect of the posterior abdominal segments.
3. Large pores with conspicuous subcutaneous tubes, these are arranged at wide intervals in a single row across each segment.
4. Smaller pores—larger than the trilocular pores—also with subcutaneous tubes.
5. Still smaller pores—smaller than the trilocular pores—with distinct subcutaneous tubes.

The dermis also carries scattered setae of varying lengths the longest of which is about 30μ in length.

Anterior and posterior osteoles present.

On *Pterocaulon decurrens* (Compositae), Mazoe, 21.viii.32; on *Trifolium* sp. (Leguminosae), Agric. Expt. Station, Salisbury, ex coll. Dept. of Agric. Salisbury, No. 2558. Attacking the roots in both instances.

In many respects this species bears a strong resemblance to *P. bechuanae* Brain, and this is particularly true of the dermal characters. *P. pterocauloni*, however, is a somewhat smaller insect and the limbs are quite different; variable though this character may be, such variation as would cover both *pterocauloni* and *bechuanae* would be unusual. The limbs are much longer in *bechuanae* and in the hind pair the tarsi are less than $\frac{1}{3}$ the length of the tibiae. The antennae also differ to a marked degree, with the 7th segment longer than, or as long as, the 3rd, whereas in *bechuanae* the 3rd is much longer than the 7th. There can be little doubt, therefore, that, although the two species are closely allied, they are quite distinct.

The specimen selected as the type is an early adult female.

Trionymus sacchari Ckll.

Cookerell, 1895, *J. Trinidad Nat. Club*, 2: 195.
Brain, 1915, *Cocc. of S. Africa, Trans. Roy. Soc. S. Africa*, 2: 63.

On Sugar Cane, Mazoe, 1.xi.27 and 23.i.28.

Rhodesian individuals agree in all respects with preparations of *P. sacchari* Ckll. from other parts of the world in my collection.

ON SOME SECONDARY SEXUAL CHARACTERS IN THE MALES OF
CERTAIN INDIAN MOTHS

By H. ELTRINGHAM, D.Sc., F.R.S.

[Read 18th November, 1936.]

WITH PLATES 1-3.

ON several previous occasions, when describing histological structures I have appealed to collectors for material in a state of preservation adapted to similar research. My indebtedness, and that of Entomology in general, to the many kind friends who have assisted in this way, has lately been greatly increased by the generosity of one of our Fellows, Mr. D. G. Sevastopulo of Calcutta, who supplied a collection of moths representing some twenty-two species, carefully named, fixed, and packed in tubes. Probably no single collection of insects has revealed such a wealth of curious structures. The work of examination has occupied many months and involved the preparation of many thousands of sections and other microscopic preparations.

Ever since the publication of the late Fritz Müller's papers, about 1877, our knowledge of the brush-organs and similar male appendages in insects has been extending. This knowledge is, however, mainly confined to their form. From the observations of Lamborn and Carpenter a little is known about the epigamic use of the brushes and dust apparatus in certain Danaine butterflies (1911, *Proc. ent. Soc. Lond.* 1911 : xlvi, 1912, *loc. cit.* 1912 : lxxxiii, 1914, *loc. cit.* 1914 : cxi) and from those of Latter, it is known that the scent from the male brushes in *Euploea* may attract females from a distance (1935, *Proc. Roy. Soc. (B)* 117 : 470). On the whole, however, knowledge of structure has far outrun that of function. The microtomist's work in the laboratory must be supplemented by patient observation in the field, and whilst the task is one of great difficulty, it should for that reason prove the more attractive for those who have the qualifications for attempting it.

Whether all the organs described in this paper are scent-organs is at least unproved. Where, as in so many examples, dust-hairs are produced, there would seem to be no doubt on this point, but many of the brush-organs show remarkably little glandular structure, and the source of their impregnation, if any, is still obscure. In many species there are at least two apparently independent sets of organs. When describing an example of this kind in *Opsiphanes cassiae lucullus* (1929, *Trans. ent. Soc. Lond.* 77 : 1) I made the tentative suggestion that the products of the different organs might, by some nascent chemical action, produce, when mingled, the characteristic scent of the species. This explanation seems less applicable to many of the species here described, and one is led to think that the scents produced may have more than one function.

I am reminded of Longstaff's words at the conclusion of his well-known work, *Butterfly hunting in many Lands*, " Each discovery does but open to our view new domains of the unknown, . . . so that if we are honest, we must admit the truth of the paradox, that every addition to our knowledge does but increase the vastness of our ignorance."

Technique.

The material had been fixed in one of the Mercury Bichloride fixatives, though it had not been entirely cleared of the Mercury by subsequent treatment with Iodine, and there was a considerable deposit in the tissues. Fortunately it was found to be entirely removable by soaking in an alcoholic solution of Iodine, though in some instances the treatment had to be prolonged for several days, a treatment to be avoided if possible, since long exposure to Iodine may undo some of the previous fixation. The use of the fluid named "Solvax," supplied by Messrs. Flatters & Garnett, has enabled me to dispense with strong alcohol, benzol, cedar oil, and similar reagents, all of which tend to harden chitin. Solvax will dehydrate rapidly from 20% alcohol and mixes freely with paraffin and with xylol. It is an ideal medium for embedding purposes. I have occasionally used the Iron Haematoxylin method of staining, but have obtained very good and rapid results with Mann's Eosin-Methyl-Blue, differentiating with Dobell's fluid (see Eltringham, 1930, *Histological Methods* : 76). This method applied to sections of some of the organs described has produced a high degree of differentiation and some exceedingly beautiful preparations.

The order in which the species are described is merely that in which I dealt with them. The numbers in brackets after each specific name correspond with Hampson's numbers in *The Fauna of British India*.

Mr. W. H. T. Tams has kindly assisted me in identifying one species, the nomenclature of which was rather doubtful.

Glyphodes bivitralis Guen. (5038).

This little moth, of which only two specimens were available, has a pair of extrusible, or at least erectile, brushes on the prothorax. It would seem that scent-brushes may appear on almost any part of the body of an insect. They are found on the abdomen of many Lepidoptera, and also on the wings. I have described them on the heads of Trichoptera (1919, *Trans. ent. Soc. Lond.* 1919 : 420). Plate 1, fig. 1, is a side view, much magnified, of the anterior part of *bivitralis*. The brush is of the ordinary type, very similar to those found in Danae butterflies. It is marked *b* in the drawing and arises from a membranous bag, *m*, and in repose the hairs of the brush seem not to be withdrawn into the bag, as they are in most brushes of this type, but lie, bent at an acute angle with the bag, in a fold of chitinous and much scaled tissue, just behind the head. Plate 1, fig. 3, is a sketch of what may be supposed to be the appearance when the brushes are fully expanded, though in neither of the examples available was it preserved in this position. The brush itself does not appear to be glandular, though in structures of this kind it is not always easy to distinguish between glandular and active trichogenic cells. The hairs arise from sockets of the usual type, each communicating with an active cell, showing in stained preparations a conspicuous nucleus. The hairs call for little remark. They are faintly fluted and very thin-walled, the latter feature being rather characteristic of brushes which secrete their own scent material. If the cells adjacent to the hair-sockets are not glandular, it is difficult to decide whence comes the secretion which the brushes are assumed to diffuse. In the fold in which the brush lies, there is a small patch of tissue, a section of which is shown at fig. 2. Whilst the fold itself is generally concave to accommodate the brush, this patch has a convex surface and is covered with scales. These can be seen in section on the upperside of the figure. A

double layer of cuticle lies beneath the scales, and between the two layers there is a small mass of tissue which may conceivably be the source of the scent material, though its structure is not of any glandular type with which I am familiar. It appears to be divided into separate cells, and these stain darkly near the outer surface. They contain many small elongated vesicles, which look like cracks in the cytoplasm, but there is no granulated structure such as one would expect in a secreting cell, nor are nuclei clearly defined.

Two separate pairs of scent-organs in the same insect are by no means unknown, but the second pair of organs in *bivitralis* are of a type hitherto unknown to me, though having certain slight analogies with those of *Lithosia griseola* (1935, *Trans. ent. Soc. Lond.* 83 : 7). At the extremity of the abdomen there is a mass of stiff black hairs, separable along the median line into two external brushes. The hairs arise partly from the basal end of the segment, and partly from a membranous process lying on the outer side of the clasper. Between this membrane and the clasper there is a large brush consisting almost entirely of "dust-hairs," i.e. hairs which readily break up transversely into minute particles to form a fine dust, presumably impregnated with a scent material. The occurrence of hairs of this type is not uncommon. The first reference known to me is that of the late Fritz Müller (1878, *Arch. Mus. Nac. Rio Janeiro*, 3 : 41). Müller found what he called articulated hairs in the costal folds of certain HESPERIIDAE. I described similar structures in the brushes of Danaine butterflies (*loc. cit. supra*) and also in the moth *Lithosia griseola* above referred to. It was some time before I could discover a probable source of any secretion which might impregnate the dust-hairs in *bivitralis*. They appear to be in the clasper. Plate 1, fig. 6, is a drawing of this organ as it appears slightly stained, cleared, and mounted whole. Between the two delicate cuticular surfaces there are many unicellular glands. Each has a socket like a scale socket, but there are few scales. Some give rise to hairs, but many appear to open on the surface through the now scaleless socket, an arrangement which is familiar in the wing-glands of Danaine butterflies. At fig. 4, I have drawn a few fragments of the dust-hairs. The whole brush is very voluminous and must contain many thousands of these hairs. Three principal types occur, though there are intermediates and the forms merge more or less into one another. There are hairs of large diameter without any cross-striation near the base, though the signs of transverse cleavage begin to appear more distally. There are hairs of medium size, with marked cross-striation which develops distally into actual cleavage, though intermediately each particle or segment is attached to the next by a fine filament, and finally there are extremely fine hairs, continuous proximally, but breaking into very fine dust in the distal parts of the brush. The diameters of the hairs vary from about .003 mm. to .008 mm. The whole "powder-puff" is more complicated than any I have so far observed. The respective uses of the two different sets of organs in this species remain to be discovered.

Glyphodes bicolor Swains. (5046).

This species has no thoracic brushes, but shows a development of dust-hairs in the abdomen, and glands in the clasper, similar to those in the previous species. The differences hardly warrant separate figures, but the dust-hairs are of a slightly different form, the segments into which they break having concave sides, giving them a bilobed appearance. The clasper differs in having more closely packed gland-cells, forming in some areas a continuous

tissue, whilst instead of hairs there are tufts of scales especially at the terminal edges. These scales are faintly striated and have a heavily granulated surface. They may be porous, but very minute pores in such organs are always difficult to determine with certainty, owing to the similarity, under a high power, of pores and nodules.

Glyphodes indica Saund. (5054).

The extremity of the abdomen of this species has a pair of very beautiful brushes formed from spatulate scales of differing lengths. I have illustrated the structure on Plate 1, fig. 5. In the inactive state they lie pressed against the sides of the abdomen. Each tuft arises from a cuticular projection, having at its apex a slight concavity. Whether these fan-like tufts are themselves glandular I am unable certainly to decide. The scales of which they are formed arise from a layer of darkly-staining and apparently active cells, a feature rather suggestive in itself, since the trichogenes of inactive scales are usually aborted. The claspers have many scent-scales arising from active cells, and there are very large dust-hair brushes similar to those in the species already described.

Glyphodes hilaralis Wlk. (5012).

Of this species I have had only one example and the brushes had been removed and sections made before I realised that the claspers might contain the glands. The outer black brushes are exceptionally large and are double as shown in Plate 1, fig. 9. The inner pair enclose dust-hair brushes as in the other species described. The trichogenic cells at the bases of both the ordinary and dust-hairs are active.

Glyphodes vertumnalis Guen. (5015).

This species has the usual large anal tuft and a great mass of dust-hairs. The fragments into which these break are very similar to those of *bivitralis*, but the connecting thread is, before separation, rather more conspicuous, so that the unbroken structure has a remarkable resemblance to a piece of cable-chain. The clasper is somewhat thickened along its lower edge, but does not show the glandular structure of that of *bivitralis*. The hind tibiae are provided with conspicuous brushes as shown in fig. 7, and there is a tuft of scales on the inner margin of the hind-wing. The significance of these features is obscure. Sections of the tibia and of the wing-tuft do not exhibit any structures which would warrant their being regarded as scent-organs. The modification of the hind tibia suggests a sense rather than a scent-organ, since there are groups of minute "sensory pits" on the chitin, but preparations of fresh material by one of the metallic impregnation processes would be necessary to confirm this hypothesis.

Glyphodes negatalis Wlk. (5010).

Only one example of this species was available. The distal extremity of the abdomen was sectioned, and the sections show so complicated a structure that further material is necessary for a complete study of the various parts. The claspers were too much disintegrated for an accurate reconstruction of their form. The whole armature is enclosed by two thin lateral plates or valves, bearing on the outer surface numerous elongated scales forming an outer brush. These plates are considerably thickened at the posterior ex-

tremity and between the walls of the thickened portion there are bodies which have the appearance of transverse sections of muscle, though the presence of muscle in this position seems improbable. Within these lateral plates there is a very voluminous mass of dust-hairs, which arise from sockets resting on a layer of active cells. The most remarkable feature of the apparatus is, however, an intermediate brush, in the form of a core embedded in the dust-hairs. The hairs of this brush are of comparatively large diameter (about .01 mm.). The hair-walls are extremely thin, and quite obviously perforated by pores over a large part of their length. The surface is almost smooth, only the faintest striation being visible under a high magnification, and the distal ends are either pointed, or more frequently forked, having two or three prongs. Each hair arises from a socket, the base of which is surrounded by a mass of cytoplasmic material. The sockets rest on a layer of cells with large nuclei and plentifully supplied with tracheae. It is difficult to resist the conclusion that these hairs supply the impregnation for the dust-hairs. The latter differ slightly from those in other species described, in the fact that the particles into which they break are of smaller average size. I have not attempted to draw any of the sections, since an illustration based on only one point of view is liable to be misleading. At fig. 8, however, I have illustrated the terminal parts of some of the perforated hairs, which form the "core-brush." There is a small fork near the base of the antenna, ending in a tuft of hairs. I have made sections of this, but cannot find anything remarkable in its structure.

Sylepta lunalis Guen. (4989).

Between the outer cuticle and the claspers there lies a pair of large brushes, which do not, however, exhibit any remarkable features. The hairs arise from a layer of very active cells. There are no dust-hairs.

Amyna (Ilattia) octo Guen. (1834).

The armature and appendages of this species show the very complicated structure illustrated at fig. 10. The example is rather widely spread out and viewed from the underside. The central spindle-shaped object is the aedeagus, behind and around which is seen the outline of the uncus. The aedeagus is set with numerous spiny projections. On either side of the uncus there is a peculiar process covered with chitinous projections which when further magnified show the form illustrated at fig. 11. These projections rather suggest a many-fingered glove, but the number of "fingers" varies from six to twelve. They arise from sockets resembling a "ball" or "universal" joint. Following outwards from the centre line come the claspers which resemble folded leaves, and each has a long terminal process. Outside the claspers lies a pair of plume-like brushes, the fine hairs of which are curved inwards. Lastly at the base of each of these is a second, rather voluminous brush, arising from a convex, button-like mass of sockets. If there is any scent apparatus in this species it probably lies in the last pair of brushes. There is no dust apparatus nor any apparent evidence of glands.

Nanaguna breviuscula nigridisca Hamps.

One might say that the development of brush-organs in this species has run wild. Adequately to work out the histological structure of all its curious appendages would require many more than the two examples available.

Plate 1, fig. 12, is a sketch of a side view of the body of the insect as it lies in a watch-glass. Three lateral brushes are at once evident. A thoracic brush projects from a point just below the attachment of the hind-wing, and two more arise from the abdomen. They are composed of very fine hairs which lie flat on the preserved specimen but are probably erectile during life. I have been unable to find any glandular tissue associated with the thoracic brush. The anterior abdominal brush is curved round at its base, forming a kind of vortical cavity in the cuticle (Plate 1, fig. 12, v). This cavity is lined with extremely delicate, many-pointed scales resting on a layer of tissue, which although staining readily does not show a definitely glandular structure. The posterior abdominal brush shows no external peculiarity, but seems associated with the anal brushes in a rather complex way. If the anal segments are opened out and the armature removed, some idea of the relative arrangement of the parts can be obtained, though the resulting displacement precludes a correct representation of their position in the natural state. Plate 1, fig. 13, is a diagram which may help to explain the structures. At *a* there is a flat mass of long dark-coloured scales, and on either side of this lies an extrusible brush *b*, *b*. Somewhat anterior to the bases of these brushes there can be seen two small swellings *s*, *s*. These lie under the cuticle and adjacent to the bases of the posterior abdominal brushes *ab*, *ab*, already mentioned. On dissecting out one of these swellings it was found to consist of a very small auxiliary brush, formed from rather spatulate hairs or scales which show a slightly glandular structure at the sockets. The extrusible brushes *b*, *b*, have no glands, but at the base of the central pad *a*, there is a small quantity of tissue which may have secretory properties. The whole system is extremely complex and many sections in different directions would be necessary for a complete elucidation. The armature itself, not shown in fig. 13, is of the peculiar form shown in fig. 14, as seen from the underside. The uncus, *u*, is in the usual form of a hook, and has two small spines at its apex. The claspers are profoundly modified and seem to be represented by the two curved processes *p*, *p*. They are clavate and the thickened terminal parts are set with numerous minute spines. I have not found in any of the above described organs any well-marked glandular development. The hind-wing, on the contrary, has an unmistakable and well-developed scent apparatus. Plate 1, fig. 15, represents the upperside of the right hind-wing, and on the anterior margin there is a mass of hairs, lying on a patch of scent-scales, *p*. In this position there is an intermembranous layer of gland-cells, particularly numerous in the nervure and well supplied with nerves and tracheae. The underside of the fore-wing also has some special scales and hairs, in the corresponding position, with a slight glandular structure.

Argina cribraria Clerck (1275).

I mention this species here because a single example was included in the collection sent me, but I could find no special organs in or upon it.

Polydesma umbricola Bsd. (2423).

The thorax and legs of this moth are so thickly covered with masses of "fur," that it is difficult to distinguish between special organs and the specifically dense clothing of the cuticle. The only apparent scent-organ I have been able to find is a small lateral brush on the metathorax lying just ventro-anteriorly to the operculum of the tympanic organ. Plate 2, fig. 1, shows a

lateral view of this region. The tympanic organ is in the abdomen but its extended opening is covered by an operculum *o*, projecting from the metathorax. Just below the base of this there is a rather flat brush *b*, arising from a slightly plicate membrane. Sections of this organ show the structure illustrated at fig. 2, where the membrane, *m*, is set with scales, and in the lumen there is a small quantity of apparently rather shrunken tissue, *t*. This tissue has a faintly granular cytoplasm, many minute vacuoles, and a few darker particles which may be nuclei, but cellular structure is not very clearly defined. I am not at all certain that this tissue is glandular. To the right of the figure is the part of the membrane carrying the brush-hairs, the bases of a few of which are shown. Beneath the sockets is a layer of modified hypoderm *g*, which I take to be the glandular part of the brush. The legs of this moth are densely clothed with hairs, and the fore-legs especially are provided with immense tibial brushes. I have made sections of these, and find that the tibiae and a large tibial spine are studded with sensory pits. There is no glandular structure, and, as in *Glyphodes vertumnalis*, the whole apparatus seems to be sensory. The armature has none of the elaborate brush apparatus described in some of the foregoing species, but is nevertheless of a very remarkable form. I have shown a dorsal view on Plate 2, at fig. 3. The uncus, in the centre, is very slender, curved downwards, and of the usual form, but the claspers are highly modified. The small projections on each side of the uncus are difficult to represent in dorsal view, but they are rather of the shape of a cork-screw of extremely coarse pitch, while externally to these projections there are bunches of stiff, heavily chitinised spines, of which in the specimen figured there are four on one side and five on the other. Posteriorly and in the centre is seen the aedeagus sheath, but the aedeagus itself has been removed. It is about the same length as the whole of the rest of the organ, viz. about 8 mm., only about 2 mm. less than the entire length of the abdomen of the insect.

Remigia frugalis F. (2574).

This species has two very large brushes arising from the prothorax, just beneath the attachment of the fore-legs. Plate 2, fig. 4, shows a somewhat diagrammatic ventral view of the anterior part of the insect, the fore-legs being set back in a rather unnatural position, and other parts removed, to show the position of the two brushes. All the legs are densely clothed with hairs and scales, and the hind-legs are of rather unusual form, being evenly fringed with scales throughout their entire length, reminding one of the swimming legs of some aquatic insects. No doubt this feature is referred to in the generic name. Fig. 5 is a drawing of this leg. There seems to be no glandular structure external to the two prothoracic brushes, they are not extrusible from a brush-bag, but are doubtless erectile by direct muscular movement, though it is hardly possible from the preserved and contracted specimen to be sure of their appearance in the living insect. Sections of the brushes stained with Mann's stain show a rather complicated structure. Plate 2, fig. 7, illustrates the appearance of a single hair-socket under the $\frac{1}{2}$ -inch objective. The hair, of which the basal part is shown at *h*, is thin-walled and very faintly reticulated, and probably permeable. It is inserted in a peculiarly massive chitinous socket *s*, the proximal parts of which are distended and reflexed in the form of lobes. The tubular part of this socket is filled with a mass of cytoplasmic material *c*, which takes the blue element of the stain. This mass rests on a layer of cells *c*, which, for the most part, stain red. Nuclei are not well marked

but darker particles are sometimes seen. Below these cells is a thin cuticle, *cu*, which takes the blue stain. There seems little doubt that the brush provides its own secretion.

The armature though characteristically complex does not suggest the presence of any scent-organ, nor are there any special organs on the wings.

Thalassodes veraria Guen. (4106).

Of this species only one example was available. On removing the wings, on which there are no special organs, there appears to be a large glistening swelling on the coxa of the hind-leg. From an aperture in this, there protrudes what at first sight might almost be a congealed fluid. It is, however, a mass of extremely fine hairs, about .001 mm. in diameter. Plate 2, fig. 6, is a drawing of this unusual modification of the hind-leg. The mass of fine hairs is seen protruding at *m*. At the junction of the coxa and femur there is a small tuft of scales, *h*, and the tibia has a large brush of rather stiff hairs, *t*. The fine hairs of the coxal organ are so easily detached that the greatest care is necessary in dissection. The opening in the coxal receptacle is bordered by a regular row of glistening scales, and on the side opposite to that shown in the drawing, the whole receptacle is outwardly scaled in a similar manner. I have made sections of the organ, and they show that the whole of the swollen part is filled with a dense mass of the fine hairs already mentioned. They arise from a trichogenic membrane studded with thousands of minute hair-sockets, and beneath the sockets there is a layer of small cells, resembling those found in the scent glands of wings. The scales which cover the outer surface of the organ lie on a somewhat thicker layer of vacuolated tissue, strongly suggesting a further source of secretion. There is little doubt that the fine hairs form a dust material, though there are no regular constrictions corresponding with points of fracture as in the usual dust-hair formation. There is a bundle of muscle fibres beneath the tuft, showing that it is probably extrusible by fluid pressure and can be retracted. Plate 2, fig. 8, represents a small part of the cellular membrane, and the basal parts of a few of the slender hairs.

On dissecting out the armature, and viewing it from the ventral side, there can be seen a pair of ventro-lateral brushes, arising at the base of the vinculum, and if one of these be removed entire with its attachments, it is found to contain as a core a membranous bag. This is turned on itself in a multiplicity of folds and the hairs arise from what, if it were fully expanded, would be the outer surface of the bag. Fig. 9 shows the basal parts of two of the hairs with their peculiar attachment to the membrane. There is no very obvious socket. The rugose membrane swells out suddenly and is attached to the hair. Just at the base of the hair there is a small mass of protoplasmic material which stains bright red with Mann's stain, while the membrane stains blue. In some places this red-staining substance extends inwards in the form of a rod. The whole structure presents a very complex appearance in its retracted state, but it suggests that when the organ is protruded by internal fluid pressure, it would present the form, not of an ordinary extruded brush, but of a small balloon, covered rather sparsely with hairs.

Nephopteryx paurosema Meyr. (4363).

On the underside of the hind-wing of this species there is a complicated organ represented on Plate 2, fig. 10. In the preserved example the whole

apparatus is so tightly rolled up that it is not easy to unfold it without damage, nor with the single specimen available has it been a simple matter to identify the various parts in section. The whole wing is about 7 mm. long. Near the base there is a little tuft of spatulate scales, *t*, arising from a small stalk. Beyond this the wing-membrane is very deeply folded. The fold is lined with numerous broad glistening scales, and contains a brush, *b*, of long spatulate scales. The inner margin is also thickly scaled. On the nervure *n*, there is a flat fold which projects from the upperside of the wing. I have not been able to indicate this in the drawing. Owing to the complex folding of the membrane, sections present a rather confused appearance. It is, however, possible to identify the principal structures. The scales of the tuft *t* are not remarkable. They arise from ordinary sockets, beneath which there is a small quantity of cytoplasmic material. The brush *b* is formed of very long scales of rather variable shape. Many are flat and broad throughout their entire length, though broadest at the distal ends. Others are very narrow except at the distal end where they are widened to a paddle-shaped extremity, the edges of which are folded over, in the manner suggested in fig. 11. In many places the cuticle of these scales is perforated by minute pores, though as there is little or no glandular material in their sockets, I cannot regard the scales themselves as secretory. Assuming the whole apparatus to be a scent-organ, the secretion must be supposed to come from the small flat scales lining the wing-fold in which the brush lies, since the sockets of these communicate with numerous intermembranous glands, of the kind commonly found at the bases of scent-scales.

The armature is so complicated that I have not ventured to illustrate it from the single example available. Adequate description would almost require the construction of a model built up from a series of dissections of several specimens. The claspers are long and the ventral edge is densely covered with glistening scales. On each side is a long brush, but the most unusual feature is a kind of secondary armature comprising two pairs of complex chitinous structures, all of which arise from the bases of the main claspers.

Cnaphalocrocis medinalis Guen. (4814).

This little species has an organ on the costal region of the fore-wing, a scale-tuft on the fore-leg, and two very slender brushes arising from the base of the armature. Plate 2, fig. 12, is a diagram of a partly cleared fore-wing. The costa is densely scaled, and above the end of the discoidal cell there is a double row of large curved scales. In the cell there is a small "brand" of short narrow scales. A stained wing mounted flat and examined under a high power shows numerous very small unicellular glands, especially plentiful about the nervures. The whole structure suggests a mass of scent-scales or "androconia," of the type now well known in many Lepidoptera. Sections of the wing show very little as the gland-cells are so flat that they become inconspicuous. Sections of the scale-tuft on the fore-legs show no glandular structure. The two small armature brushes are not themselves glandular, and if there is any secretion it would appear to come from the claspers, which are covered with large but very delicate scales, each arising from a socket, beneath which is a deeply staining body indicating the presence of an active cell. Along the edge of the clasper there is a row of hairs, the sockets of which are connected with a nerve fibre. All the nerve fibres proceed from a conspicuous nerve cord, and the whole arrangement forms a sensitive tactile organ.

I mention this feature especially in connection with this species as it is unusually distinct. I would, however, point out that all the claspers examined have a fairly complete nerve supply. Most of the thousands of male armatures which have been described and figured have been prepared by boiling in caustic so as to leave only the harder parts. One is thus led to think of the claspers as mere mechanical organs whereas they are well equipped with nerves, muscles, and tracheae, and are undoubtedly organs of complex structure and function.

Marasmia venitalis Wlk. (4815).

On the costa of the fore-wing there is a mass of scales and the area covered by them is much thickened, projecting as a swelling from the underside of the wing. The fore-legs have tufts, very similar in appearance to those of *medinalis*. There are two slender anal ventro-lateral brushes arising near the bases of the claspers, and between them a tuft of hairs, of about the same length. The brushes are not extrusible from a brush-bag, but are probably erectile. They do not appear to be self-secreting. If sections be made of the swollen area on the fore costa, it is seen, as in Plate 2, fig. 13, to be a concavity in the wing covered by a layer of large protective scales, *s*, and containing scent-scales, *sc*, and very fine dust-hairs, *d*. These are not more than .001 mm. in diameter, and often less. They are not constricted at regular intervals, but seem readily to break, not into short dust-particles, but into spicules. They arise together with the scent-scales from a thin glandular intermembranous layer of the wing. It is not easy to suggest how the dust-hairs are diffused, unless possibly it is by rubbing with the feet. This type of organ has been known for many years, as already mentioned in the earlier part of this paper. Westwood, 1852, *Gen. diurn. Lep.*, observed it in HESPERIIDAE, and Herrich-Schaeffer, 1868, *Prodrom. Syst. Lep.*, referred to it as the "costal fold." It was Müller, however, who, as already stated, first found the "dust-hairs" in 1878.

The clasper, fig. 14, is not complicated but bears some interesting structures. The outer side is densely covered with hairs and the inner side has both hairs and scales, most of which point away from the posterior end. At *p*, there is a small process with a clavate extremity bearing several spines, each of which has a nerve-thread entering its base. At *s* there is a clothing of scales, all directed anteriorly, and of a form which is new to me. Three of them are shown much magnified at fig. 15. At the broad end there is a slight granulation, and just proximally to this there is a disc-like structure, also granulated. There do not appear to be gland-cells at the bases of these scales, and their function is not evident. There are numerous protoplasmic granules in the clasper, but they do not suggest the marked glandular formation found in some of the other species here described.

Botyodes asialis Guen. (4948).

There do not appear to be any special organs on the wings, thorax, or legs of this species, but a preliminary dissection of the distal end of the abdomen, made by cutting ventrally and turning back the overlying cuticle, discloses two large masses of scales, Plate 2, fig. 16, very closely packed, and lying against the outer surfaces of the claspers. These fall away at a touch and removal of the organ intact is almost impossible. Beneath this scale-brush there is a voluminous mass of dust-hairs, also very easily detachable. The outer scales are long, very delicate, and have a granulated appearance sug-

gestive of pores. They are almost certainly permeable. The dust-hairs vary somewhat in thickness, and for the most part do not break into separate nodules, but into slightly spindle-shaped groups of five or more segments, having the form shown at fig. 17. Owing to the tendency of the organs to disintegrate, and there being only one example available, I have been unable to secure a good whole section, so that it is difficult correctly to correlate the structures. The long scales of the outer layer arise from deep funnel-shaped sockets beneath which lie active cells closely associated with tracheae, as shown in fig. 18. The dust-hairs arise from correspondingly small sockets, but in most places the layer of cells beneath them is thicker, though the cells are smaller as in fig. 19. The transition from the thin layer of large cells to the thicker mass of small ones is not well marked. Whether both classes of cells are secretory, or one of them trichogenic I am unable to decide.

Lepyrodes neptis Cr. (5069).

The fore-legs are densely clothed with long hairs so that the tarsi are hidden by them and have the appearance of brushes. The mid tibiae are also covered with long scales. Sections of the fore tarsi and other parts of the legs, show no special structures, indeed there is a remarkable absence of cellular tissue. There is a peculiar organ on the underside of the metathorax (Plate 3, fig. 1). The illustration shows a view of the underside of part of the thorax after removal of the head and front legs. Parts of the metathoracic legs are shown.

Just below the attachment of the wings there are two small cavities *cc*, each having a narrow rim on the inner side coated with small scales. On the outer side there is a mass of large spatulate scales forming a cover for the cavity. In the cavity there is a minute tuft of a few small scales. Sections of this organ show only the very slightest development of cellular structure at the bases of the tuft and covering scales. Indeed there is little more than a thin membrane, with the usual scale sockets, and a few granules visible only under the highest powers. There is nothing to provide a clue to the function of this organ. The armature when dissected out has at first the appearance of bearing two slender brushes, but these are found to be merely long hairs or scales emanating from the outer surface of the claspers. The latter are of very simple structure without any remarkable appendages, but a stained example, mounted whole, shows a layer of cells between the outer and inner cuticle. Cells of this character are not unusual in the claspers of some of the moths examined. Plate 3, fig. 3, is a diagram of the clasper merely to show the position of the majority of these cells, which in the shaded area are somewhat thicker than elsewhere. Traces of them, much attenuated, can be seen over most of the area of the clasper. At fig. 2 I have shown a few of the cells more highly magnified. They are very irregularly pentagonal, though the sides may sometimes be rounded. There is a dark-staining centre from which several dark lines radiate. They may conceivably be modified fat-cells, though they lack some of the characteristics, notably the usual vacuolated appearance, of typical fatty tissue.

Crocidolomia binotalis Zell. (5076).

In this species there is a costal tuft of folded scales on the fore-wing, as shown in Plate 3, fig. 4, *t*. It does not contain dust-hairs as found in some of the other species here described. A wing stained, cleared and mounted,

shows no very noticeable intermembranous cellular development. If there are any secretory cells they must be very minute. If an insect be examined from the underside there is found, on the prothorax, an extremely complex apparatus, and fortunately several specimens were available, otherwise it would have been impossible to make anything like an exhaustive examination. By spreading out a specimen on a block of wax, under alcohol, and stretching the parts with small pins, I secured a preparation showing as much as can be seen in a single view. It is illustrated at fig. 5, though owing to the treatment described, the relative positions of the parts are considerably distorted. The "neck" has been extended to show the points of origin of the two brushes, *bb*. At *cc* are the coxae of the fore-legs. These normally lie pressed together and more or less parallel with the long axis of the body. Beneath the coxae, from the ventral view, there lie two delicate sheaths, *ss*. These really arise at the bases of the brushes. They are formed from a thin, rather "silvery" membrane, clothed with large but very delicate scales. In the inactive position the brushes lie in these sheaths, which are closely folded round them, but when unfolded, the sheaths are capable of opening along the whole of the outer side. The brushes are not extrusible from a bag, like those of a *Danae* butterfly, but are erectile, and each has a small chitinous lever with a muscle attached thereto. If there is some doubt as to the glandular nature of some of the brushes already described, there is none in respect of the brushes of this species. Plate 3, fig. 7, shows, in section, a fragment of the basal part of one of them. In the drawing, *ch* is part of the erectile apparatus, and there appear to be two kinds of hairs, or at least hairs arising from two kinds of sockets. At *h* are the bases of a few hairs arising from very short sockets, and at *hh* there are hairs of which the sockets are long and trumpet-shaped. Both kinds have conspicuous gland-cells beneath them, and although in the particular preparation illustrated, the shorter sockets have the larger gland-cells, this is not so in all sections, and the depth of the gland-cells seems to vary, irrespectively of the form of the sockets.

The structures on the coxa are better described from fig. 6, which is drawn from a point of view slightly different from fig. 5, and under a higher power. On the inner ventro-lateral part of the coxa is a concavity *cy*, sparsely set with small dark-coloured scales, and basally from this there is a much deeper concavity *c*, covered by a peculiarly shaped object *p*. At first I took this to be a curiously-formed chitinous plate. It is actually a mass of curved scales, so tightly fitted together as to have the appearance of a continuous structure. The mass is easily detached entire, and only when attacked with needles is it found to be composed of scales. Beneath this shield the concavity contains a voluminous mass of extremely slender, spatulate-ended, scales or hairs, which do not break transversely, but are so numerous and delicate and so easily detached that they suggest the same sort of function as the dust-hairs found in other species here described, and seem especially comparable with the coxal brushes of *Thalassodes veraria*. A few of them are shown protruding at *sp*, fig. 6. Sections of the coxa, fig. 8, show an extreme complication which it would require more material than is at present available fully to elucidate. The plate-like mass of scales on the outer part of the cavity shows, in section, that its components surround the very fine inner tuft, in whorl-like formation. All the scales and hairs of the finer tuft arise from conspicuously glandular sockets. The fine scales of the inner tuft are of at least two forms. Both are broader at the basal part, and taper off into a kind of whip-lash form, but one type has a sharp bend in the broader part. I have shown the two

forms at fig. 9, but they cannot be drawn on this scale in true proportion as they are really very much longer in relation to their width. The whip-lash terminations are only about .0005 mm. thick. The "plate" or "shield" scales are of a much stouter form, and many of these are also sharply bent, though they become wider distally, instead of narrower. At their distal ends they are sharply bent over to form a kind of locking device, which doubtless accounts for the difficulty of separating them. The armature is of a comparatively simple form, but in connection with it there are again two brushes, arising just proximally to the bases of the claspers. They are slender and present no very remarkable features. The claspers are simple and though there are a few cells along the upper and lower edges, they have more the appearance of a fatty than of a glandular structure.

Eurrhyparodes bracteolalis Zell. (4789).

There is no very elaborate apparatus in this little species but on the fore costa, rather distally placed, there is a swollen patch covered with curved scales. Plate 3, fig. 10, shows a transverse section of this organ. At *cn* is the swollen and distorted costal nervure, and at *cs* the curved scales which form a cover for the cavity, in which are seen at *dh* large numbers of dust-hairs, cut transversely. At *sc* are portions of scent-scales cut at various angles, but the glandular layer from which these arise can be clearly seen at *gl*. Longitudinally the dust-hairs have the appearance shown at fig. 11. They look like minute funnels strung together on a slender thread, and arise from curious forked bases, one of which is also shown. The diameter of the dust-hairs is about .002 mm. The armature is of very simple character, and there appears to be a very rudimentary brush, consisting of a few hairs, arising at the base of each clasper.

Sameodes cancellalis Zell. (5082).

The fore-wing of this species is curiously shaped, owing to a sudden projection at about one-third of the length of the costa. This is found to be a tuft of coiled scales, in the cavity of which there are a few smaller scales. There are no dust-hairs, and if the enclosed structures are scent-scales, the glandular development is very inconspicuous. On the metathorax, just beneath the attachment of the hind-wing, there is a small brush. Sections of this show that the hairs arise from a much folded membrane, and the organ is probably erectile by fluid pressure from within, and collapsible by the contractile elasticity of the membrane. Here again I can find no very obvious secretory apparatus. A much more complicated structure is found at the end of the abdomen. Here on removal of the cuticular tissues, two large masses of black scales are found outside the claspers, forming voluminous brushes. On the outer side of these scales is a small brush of yellow hairs, and on the inner side, lying between the black scales and the claspers, there is a second brush of yellow hairs, which when dissected out, appears to be solid, at least at the distal end. Teased with needles the hairs can be separated, but they certainly adhere rather firmly, whether through a partial fusion, or because of some congealed secretion, I cannot certainly decide. The idea of partial fusion is suggested by a recollection of the peculiar clavate brush, described by me as found in our British species, *Lithosia griseola* Hüb. (1935, *Trans. R. ent. Soc. Lond.* 83 : 7), where the distal ends of the hairs are swollen and fused together. The formation in *cancellalis* may be an approach to that

condition. Plate 3, fig. 12, shows a reconstructed section of the brush apparatus, the armature, which normally lies in the central area having been removed. At *fb* are the two inner brushes, the hairs of which appear to be partially fused together. At *bb* is one of the very thick black brushes, and at *ob* the outer brush, which is comparatively small, *c* is the cuticle. All the brushes arise from a layer, *gl*, of distinctly glandular tissue. When the black brushes are teased out on a slide, they are found to consist of scales in every stage, from extremely thin plain hairs, through a ribbon-like formation, to a structure which has the appearance of a number of broad flat scales strung together on a delicate thread. Three typical forms are shown at fig. 13. No doubt the black brushes break into innumerable fragments, and are yet another modification of the dust-hair apparatus.

The clasper contains much cellular material, especially in the distal and marginal areas. It is of the same type as that in the clasper of *Lepyrides neptis*.

Pachyzancla licarsialis Wlk. (5151).

The fore-wing costa is densely clothed with scales for about half its length, and these curl over towards the underside. They have the appearance of scent-scales. I have found no special organs on the thorax, but the armature has two lateral brushes, arising from just behind the bases of the claspers. These are formed from slender hairs, broadened at the distal ends into a spatulate form. In the preserved examples I have found great difficulty in making an expanded preparation of the whole system, as the brushes disintegrate at the least touch, though I do not think they act as dust-hairs, of the presence of which there seems no indication. Sections of the whole distal end of the abdomen show the usual relationship between the claspers and the brushes, but there is a notable absence of anything like glandular tissue at the sockets of the brush-hairs. Stained and cleared examples of the clasper show a great development of "sensory pits" along the margin, with a well-developed nerve supply, but little or no cellular structure. If there is any secretory apparatus associated with the brushes in this species I have been unable to identify it.

Pionea leucanalis Swinh. (5207).

The most striking feature of this species, of which only one example was available, is the densely hirsute tibia of the mesothoracic legs. Plate 3, fig. 14, shows the appearance of the leg cleared and mounted whole. In the condition of inactivity the tibia has a merely thickened appearance, due to the long hairs lying closely packed along its length. On opening out the structure with needles, a deep groove is found, the outer part of which is covered by a brush of fairly stiff hairs, whilst the groove itself is packed with long slender hairs, varying from .002 mm. to .008 mm. in diameter, and all constricted at intervals to form a mass of dust material. At *b*, fig. 14, is the brush proper, which at rest covers most of the tibia. At *c* are a few of the slender dust-hairs protruding from the groove. As one of the legs was mounted whole, only one was available for sectioning, and sections in one direction only do not fully show the arrangement. I have not been able with certainty to identify the sockets of the dust-hairs, but they appear to arise from the cuticle lining the groove, and there is no very evident glandular development. It is quite otherwise with the sockets of the stiffer hairs of

the brush *b*, which arise from a concavity of the tibia, near its junction with the femur. Beneath each socket is a large, more or less pyriform cell, which takes an intense blue with Mann's stain, whilst beneath and between these there are smaller cells which stain red, with bluish nuclei. Evidently the impregnation of the dust-hairs arises from this source. At fig. 16 I have shown a fragment of a section of these structures. The dust-hairs vary greatly in thickness and in the length of the segments. A few examples are shown at fig. 15. The narrowest are about .002 mm. and the broadest about .01 mm. in diameter.

Having only one specimen I cut the armature into longitudinal sections. This method gives little idea of the structure of the claspers, but it shows the presence of two well-developed lateral brushes lying against their outer surfaces. At fig. 17 I have shown the basal parts of a few of the brush-hairs. The sockets are of simple character, and the glandular development quite elementary.

EXPLANATION OF PLATES.

PLATE 1.

FIG. 1. *Glyphodes bivitralis*. Side view of head and prothorax. *b*, the brush. *m*, the membranous bag;

2. do. Section of the tissue of fold in which the brush lies;
3. do. View of anterior parts of insect with the brushes expanded;
4. do. Fragments of the dust-hairs;
5. *G. indica*. Extremity of abdomen;
6. *G. bivitralis*. Clasper;
7. *G. vertumnalis*. Hind tibia;
8. *G. negatalis*. Hairs of the "core" brush;
9. *G. hilaralis*. Anal brushes;
10. *Amyna (Istattia) octo*. Armature and appendages;
11. do. Chitinous structures from intrahepatic process;
12. *Nanaguna breviuscula nigridisca*. Side view to show position of brushes. *ts*, opening of tympanic sense-organ. *v*, vortical base of first abdominal brush;
13. do. Diagram of anal brush system. *a*, central mass of scales. *bb*, extrusible brushes. *ss*, swellings containing auxiliary brushes. *ab*, second abdominal brush;
14. do. Armature. *u*, uncus. *pp*, processes;
15. do. Upperside of right hind-wing. *p*, scent-scales.

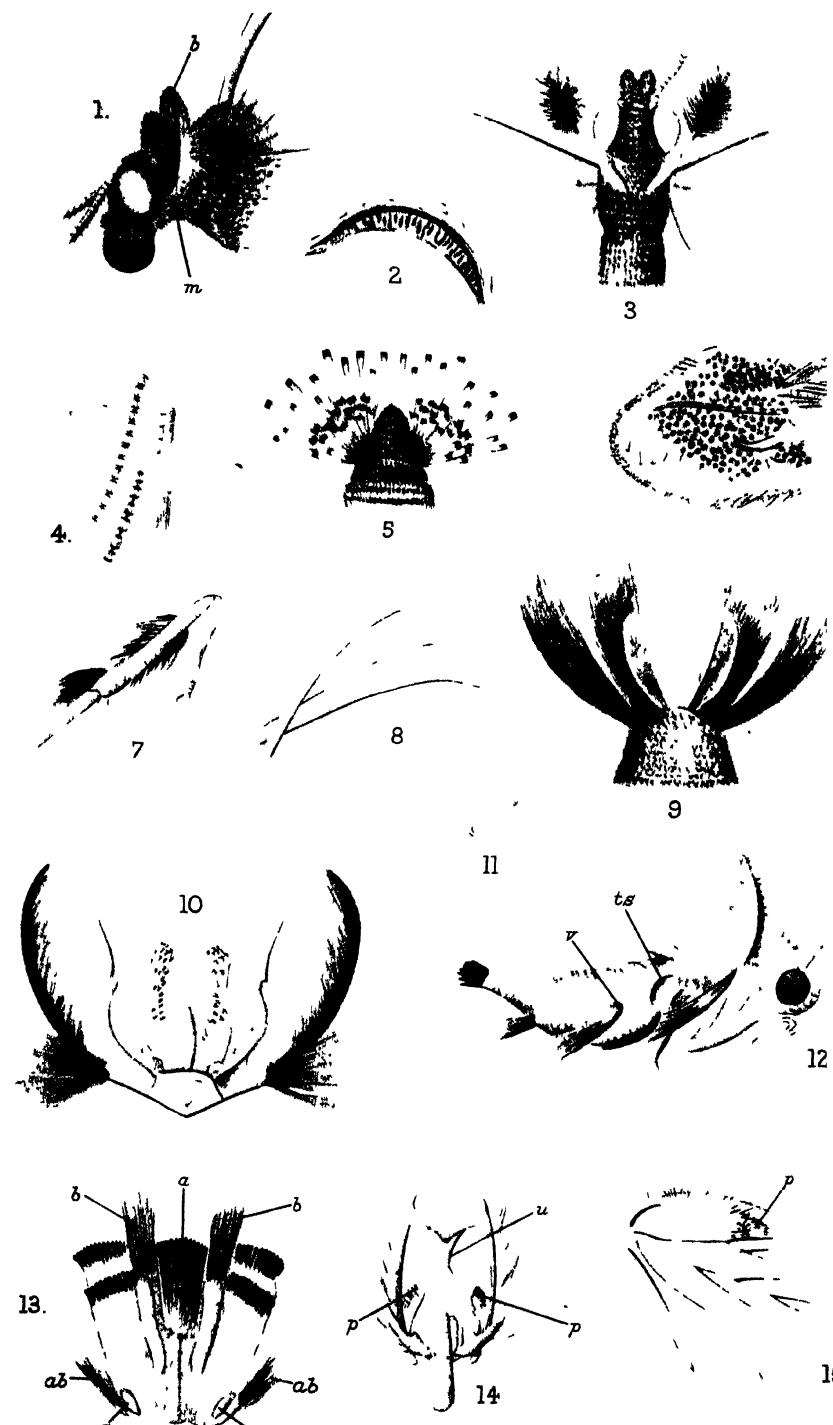
PLATE 2.

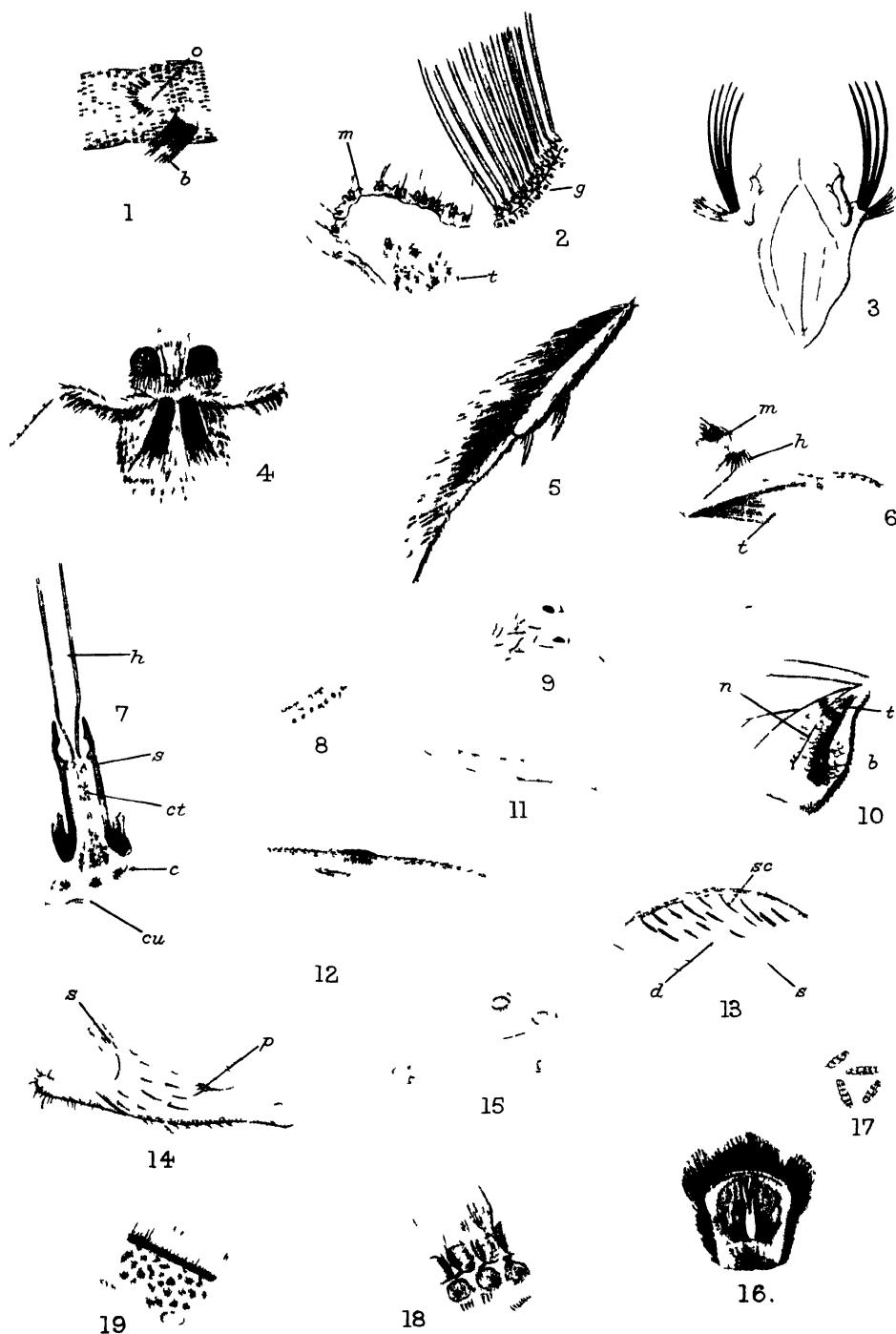
FIG. 1. *Polydesma umbricola*. Lateral view of metathorax. *o*, operculum of tympanic organ. *b*, brush; 2. do. Section of brush. *m*, membrane. *t*, vacuolated tissue. *g*, glandular tissue; 3. do. Armature. 4. *Remigia frugalis*. Underside of head and anterior parts; 5. do. Hind-leg; 6. *Thalassodes veraria*. Hind-leg. *m*, fine hairs. *h*, tuft of scales. *t*, brush; 7. *R. frugalis*. Hair of brush. *h*, basal part of hair. *s*, socket. *ct*, cytoplasmic material. *c*, cellular layer. *cu*, cuticle; 8. *T. veraria*. Fragment of membrane from concavity of coxa; 9. do. Bases of two hairs from the "core" brush; 10. *Nephopteryx paurosema*. Organ on underside of hind-wing. *t*, spatulate scales. *b*, brush. *n*, nervure from which fold projects; 11. do. End of one of the wing-brush hairs to show folding; 12. *Cnaphalocrocis medinalis*. Fore-wing; 13. *Marasmia venilialis*. Section of the wing-organ. *sc*, scent-scale. *d*, dust-hairs. *s*, protective scales; 14. do. Clasper. *p*, process with sensory spines. *s*, scales (shown more magnified at fig. 15); 15. do. Scales from end of clasper; 16. *Botyodes asialis*. Dissection of end of abdomen; 17. do. Dust particles; 18. do. Sockets of three of the outer brush-scales; 19. do. Bases of dust-hairs and cellular layer beneath them.

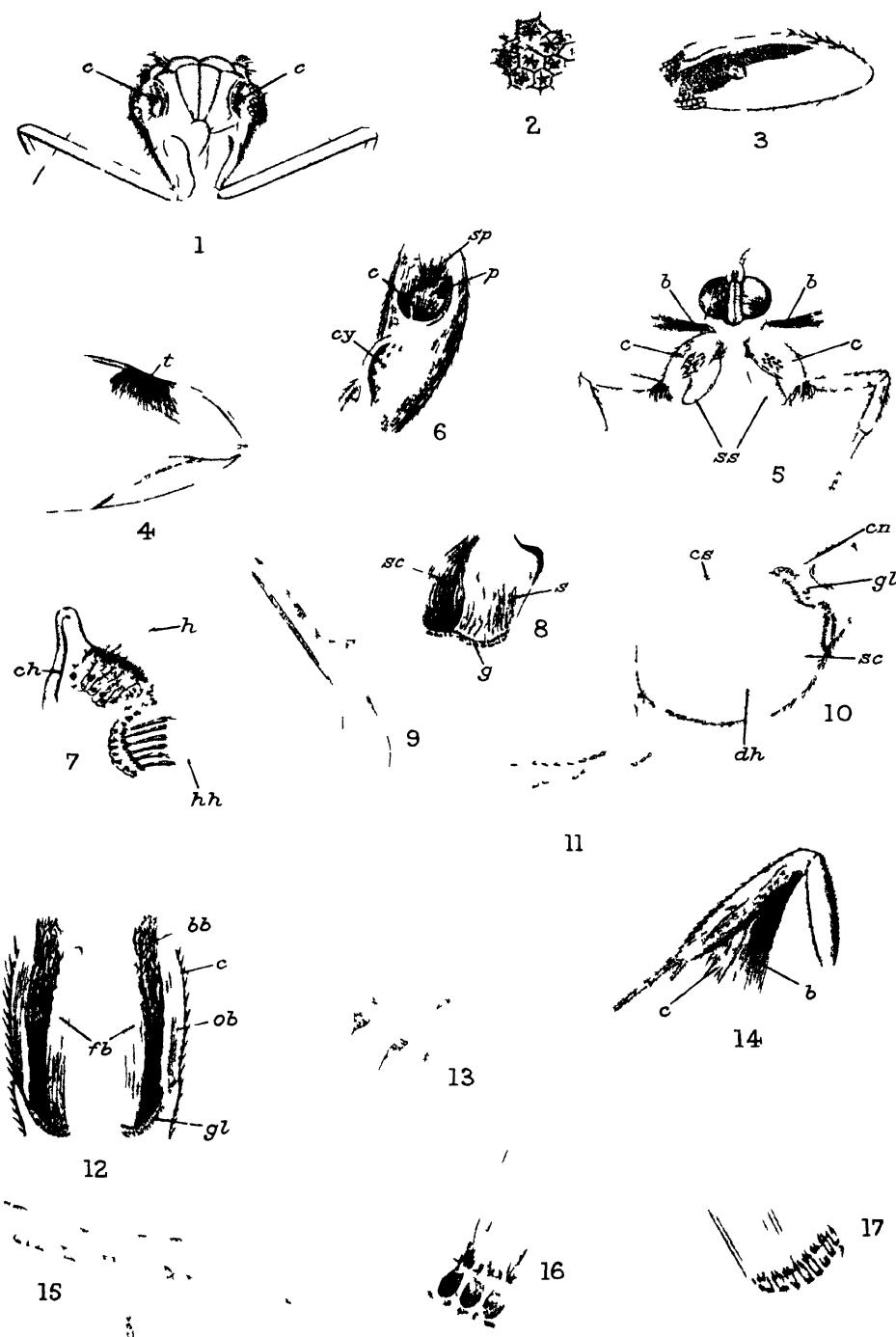
PLATE 3.

FIG. 1. *Lepyrodes neptis*. *c*, organ on underside of metathorax; 2. do. Cells from clasper; 3. do. Clasper; 4. *Crocidolomia binotalis*. Base of fore-wing. *t*, folded scales; 5. do. Fore-legs, brushes, etc., extended. *b*, brush. *c*, coxa. *s*, sheath; 6. do. Coxa more highly magnified. *cy*, scaled concavity. *p*, "plate" scales. *c*, deep concavity. *sp*, fine scales protruding from cavity; 7. do. Section of fragment of basal part of "neck-brush." *ch*, part of erectile apparatus. *h*, short-socketed hairs. *hh*, long-socketed hairs; 8. do. Section of brush-bearing part of coxa. *sc*, "plate" scales. *s*, fine hairs. *g*, glandular cells; 9. do. Fine hairs from interior of coxa; 10. *Eurrhyparodes bracteolalis*. Section of costal organ of fore-wing. *cn*, costal nervure. *cs*, covering scales. *dh*, dust-hairs. *sc*, scent-scales; 11. do. Fragments of dust-hairs from wing; 12. *Sameodes cancellalis*. Brush apparatus from terminal part of abdomen. *fb*, "fused" brushes. *bb*, black-scale brush. *c*, cuticle. *ob*, outer brush. *gl*, gland-cells; 13. do. Parts of scales from the black-scale brush; 14. *Pionea levicanalis*. Mesothoracic leg. *b*, brush. *c*, fine hairs protruding from interior of groove; 15. do. Fragments of dust-hairs; 16. do. Sockets of brush-hairs (*b*, fig. 14); 17. do. Sockets of armature brush-hairs.

Note. The magnifications vary. Some typical measurements are given in the text.







MEXICAN HYDROPTILIDAE (TRICHOPTERA)

By MARTIN E. MOSELY.

[Read 5th May, 1937.]

WITH THIRTY-SEVEN TEXT-FIGURES.

THROUGH the courtesy of Dr. Georg Ulmer, I have been enabled to examine and describe the HYDROPTILIDAE collected by Dr. Alfons Dampf in Mexico.

Dr. Dampf's collection, of which, so far, well over 80,000 specimens have arrived in this country, has been made by the use of trap-lanterns and unfortunately, in many species, it has not been possible to find a complete example on which to base a description.

This paper covers a portion of the material captured in the states of Chiapas Sinaloa and Guerrero.

Up to the present, only a single Mexican Hydroptilid has been described, namely *Leucotrichia melleopicta* Moseley, an insect found amongst the British Museum accessions and labelled "Teapa, Tabasco, H. H. S." This species was included in an account of exotic HYDROPTILIDAE published in these *Transactions*, Vol. 82, in 1934.

It is interesting to find that another genus, *Polytrichia*, of which a Jamaican species was described in the same paper, is well represented in the Mexican collection, three new species being here described. The genus *Protoptila* is represented by four and *Hydriptila* by five new species. Of the latter, it is of interest to note that in all excepting *H. mexicana*, very distinctive scent-organ structures have been observed.

Attention may perhaps be called to the new genus *Zumatrchia* of which two species are here described. This genus has the very unusual feature (in Trichoptera) of having, so far as can be seen, only two ocelli, that at the apex of the head being wanting. Moreover, the basal segments of the antennae are most unusual in form, triangular from above and attached to the head at the outer basal angles. There is also a plate projecting from each under surface. This structure may possibly function as a scent-organ.

A group of genera has been erected, *Exitrichia*, *Dolotrichia*, *Guerrotrichia* and *Lorotrichia*, which are all related to each other and also to Morton's *Neotrichia*. These genera include a large number of species and, although they could hardly be distinguished from one another on the usual characters which are accepted for the definition of genera in this family, namely neuration, spurs and the presence or absence of ocelli, yet I have deemed it advisable to separate them on additional characters derived from the genitalia in order to avoid the position that has unfortunately arisen in some of the older genera, more particularly *Hydriptila* and *Oxyethira*. Here are found a large number of incongruous forms placed in the same genus because they agree in neuration and the other customary characters, genitalia being entirely disregarded.

The Hydroptilid fauna of Central and South America is practically unknown and, in erecting what may be described as a generic framework, I hope it may be found that provision has been made for the hosts of new species that must eventually be discovered and described.

In conclusion, acknowledgment must be made here of the courtesy of Dr. TRANS. R. ENT. SOC. LOND. 86. PART 10. (TAX.) (SEPT. 1937.)

Dampf and Dr. Ulmer, who have presented all the types of species here described as well as half the Hydroptilid material in the collection to the British Museum. Dr. Ulmer, moreover, is presenting half the material of Mexican Trichoptera other than the HYDROPTILIDAE, which has been sent to him out of Dr. Dampf's extensive collection.

Protoptila Banks.

Protoptila Banks, 1904, *Proc. ent. Soc. Wash.*, 6 : 215; Betten, 1934, *N.Y. State Mus. Bull.*, 299 : 149-150, Pl. 12, figs. 1-5.

Neither Banks nor Betten in his account of this genus makes any comment on the very extraordinary genitalia of the female. In two of the Mexican species described in this paper, there is a remarkable structure of the eighth ventral segment which is produced in a very long corneous process through which passes a fine internal tube which originates in the abdomen. This tube can hardly be an ovipositor; it is present in the species *tenebrosa*, *maculata*, *lloydii*, described by me in 1934, *Trans. R. ent. Soc. Lond.*, 82, though the structure is not there mentioned. In these species, there is no long process to the eighth segment and the tube is contained almost entirely within the abdomen. This formation is found also in the Mexican species *ixtala*.

It should be mentioned that in the Mexican species there is a cross-vein at the base of fork no. 5 of the posterior wing which I have been unable to trace in other described species.

The intermediate leg of the female is considerably dilated. The females described herein have been attributed to their respective males with no very definite evidence; it can be said, merely, that as there were present only single examples of ♂ and ♀ *rota* in the Dolores collection and numerous examples of both sexes of *salta*, the probability is that they are correctly placed. It would have been more satisfactory had fork no. 5 in the posterior wing of the female *rota* been sessile as in the male.

It is perhaps open to question whether *Protoptila* should not be placed in the RHYACOPHILIDAE rather than the HYDROPTILIDAE.

Genotype, *P. maculata* Hagen.

Protoptila rota sp. n. Figs. 1 and 2.

In the posterior wing ♂, fork no. 5 sessile but with a short footstalk in the ♀ as in *salta*.

Genitalia, ♂. From above, the apical margin of the eighth dorsal segment slightly concave; intermediate appendages each with a small basal and large second segment; from above, the basal segment and the basal parts of the second segments are turned somewhat outward, presenting flattened upper surfaces, the bases of the second segments resembling a pair of ears and the terminal parts bearing slight angular projections on their outer margins; from the side, the second segment has a strong angular projection on the upper margin towards the base; penis membranous with a transverse ridge and a minute spine at the apex on its dorsal surface; there are two incurving sheaths directed slightly downward and, beneath the penis, are two very long, fine spines close together, arising from broader bases; the processes of the penis, at the base, seen in a preparation through the abdominal walls from the side, somewhat resemble an axehead and there are two small projecting teeth on the lower margin; the eighth segment is strongly produced ventrally to make a long bifurcate process, from the side very wide at the base and within it, may be seen the strongly produced ninth segment with a widely excised apical margin; a short ventral process to the sixth segment.

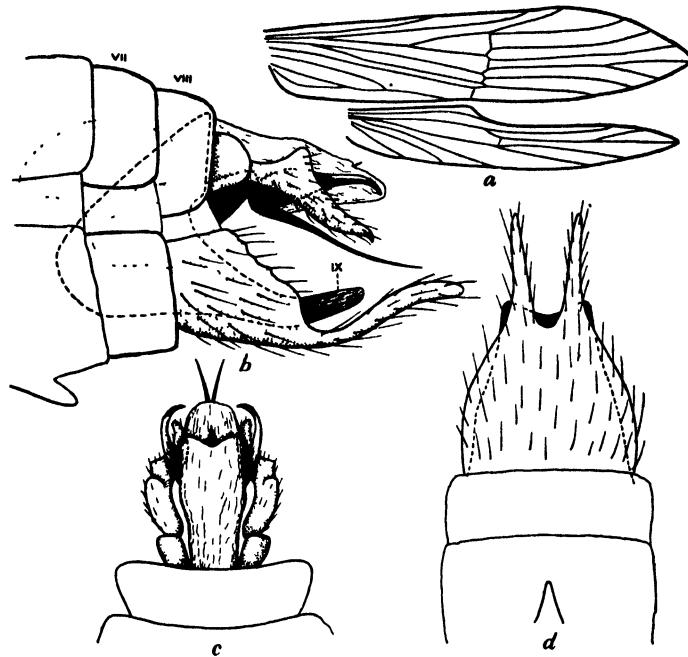


FIG. 1, *a-d.*—*Protoptila rota* sp. n. ♂; *a.* wings, *b.* genitalia, lateral, *c.* dorsal, 8th and 9th sternites omitted, *d.* ventral.

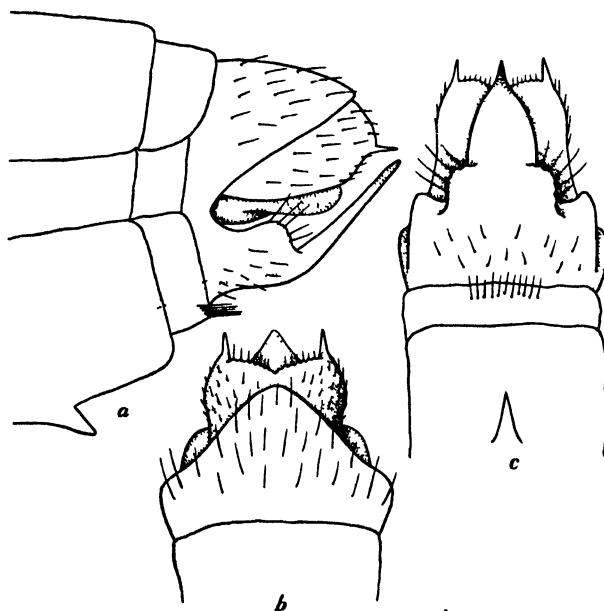


FIG. 2, *a-c.*—*Protoptila rota* sp. n. ♀; *a.* genitalia, lateral, *b.* dorsal, *c.* ventral.

Genitalia, ♀. The eighth segment from above is strongly produced at the centre of its apical margin; beyond it, the ninth segment is seen as two lobes fused together at their inner margins with a shallow excision at the centre of the slightly serrate apical margin; each outer angle is produced into a rather long, acute finger; ventrally, the eighth segment carries a long, slightly upwardly directed process with a wide base both from beneath and from the side; there is a strong process to the sixth ventral segment but none to the seventh where the centre of the margin is slightly produced and shrouded in a tuft of hairs. There is an internal tube, as in *P. salta*, extending through the process of the eighth segment.

Length of anterior wing, ♂, 3 mm.

" " " ♀, 4 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (*A. Dampf*).

Type ♂ in the collection of the British Museum; paratypes in the British Museum and in the collection of Dr. G. Ulmer, from neighbouring localities.

Protoptila salta sp. n. Figs. 3 and 4.

Antennae 23-segmented in the ♂, the middle segments enormously dilated. In the posterior wing, fork no. 5 with a short foot-stalk.

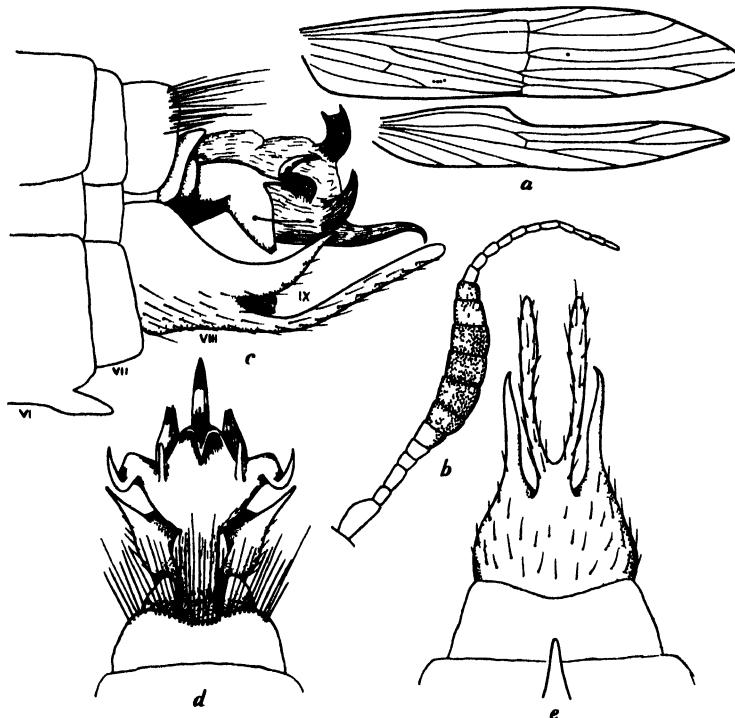
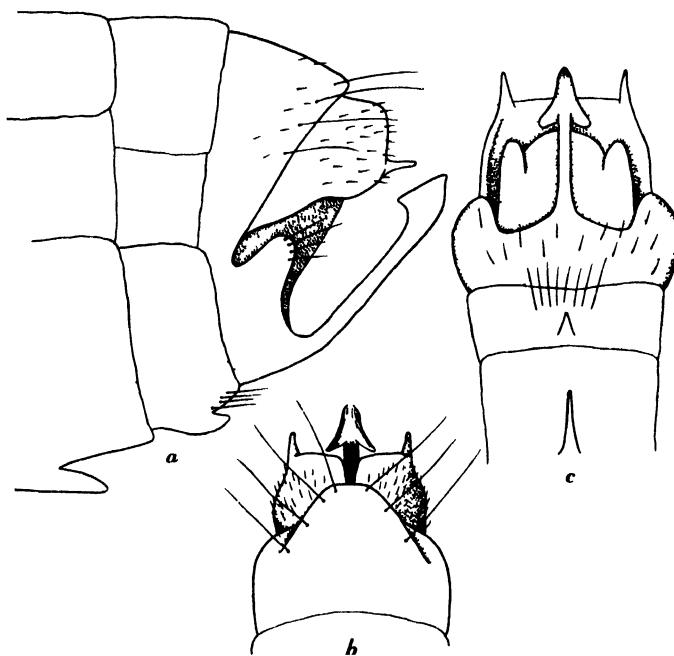


FIG. 3, a-e.—*Protoptila salta* sp. n. ♂; a. wings, b. antenna, c. genitalia, lateral, d. dorsal, 8th and 9th sternites omitted, e. ventral.

Genitalia, ♂. From above, the eighth segment is very strongly chitinised and terminates in an excised apical margin fringed with strong hairs; beneath it may be seen two triangular processes which are possibly projections from the apical margin of the concealed

ninth segment; beneath these, again, are the two-segmented processes corresponding to those which in my description of *P. tenebrosa* Walker (1934, *Trans. R. ent. Soc. Lond.*, 82) I suggested were intermediate appendages; in *salta*, the bases of these processes are short and, from the side, the second segments are rather stout and elbowed downward, each with a spur at about midway along its upper margin projecting posteriorly and outwards; the penis has an enormously dilated apex furnished with a pair of very slender, transparent dorsal rods and six hooks; the latter, from above, consist of an outer pair curving strongly upward and posteriorly, the pair of transparent rods arising at their bases; at the apex is a single upwardly and basally curving hook, broad and with a semicircular excision at its apex as seen from the side; on the lower surface and beneath the outer pair is another pair of heavily fringed hooks directed upwards and the sixth also arises from the lower



4

FIG. 4, a-c.—*Protoptila salta* sp. n. ♀; a. genitalia, lateral, b. dorsal, c. ventral.

surface and, from the side, is slender and sinuous, apex directed downward; eighth ventral segment much produced and furcate, each fork with a long and slender lower and rather wider and shorter upper branch which, seen from the side, terminates in a finger-like apex; there is a short ventral process to the sixth segment.

Genitalia, ♀. The eighth segment from above is produced at the centre of its apical margin into a blunt triangle; beyond it, the ninth segment terminates in two processes which from above and from the side are rectangular with the outer and lower angles produced into small acute fingers; there is a strongly chitinised plate beneath; ventrally, the eighth segment carries a long, strongly chitinised process extending slightly beyond the apex of the ninth segment, directed slightly upward with a sagittate apex from above and beneath, clavate from the side; from the side, the base of this process is broad and is partly separated from the tergite by a narrow, rounded excision; there is a fine tube (of unknown function) which arises from within the abdomen and passes through the centre of this process nearly

to the apex; there is a strong process to the sixth ventral segment and a smaller one to the seventh.

Length of anterior wing, ♂, 2·5 mm.

" " " ♀, 4 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (*A. Dampf*).

Type ♂ and paratypes ♂ and ♀ in the British Museum collection. Paratypes ♂ and ♀ in Dr. G. Ulmer's collection, all from the same and neighbouring localities.

Protoptila ixtala sp. n. Fig. 5.

Wings chocolate brown with five or six nearly contiguous white spots across the anterior wing at the arculus, a single spot between these and the base of the wing towards the anal region, a pair, one beneath the other at the costa, near the apex and a few round the fringe; neuration as in *P. salta* sp. n.

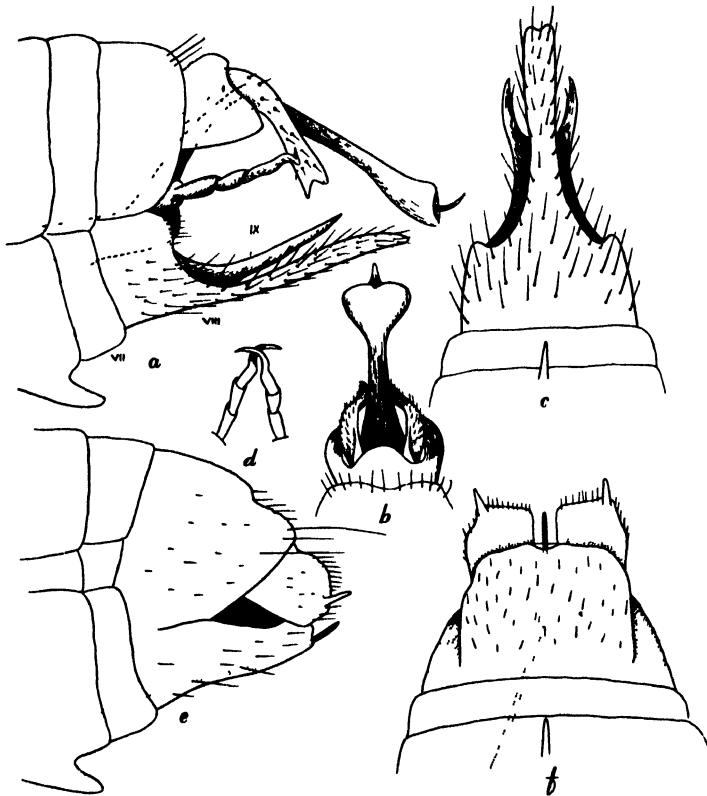


FIG. 5, *a-f*.—*Protoptila ixtala* sp. n. ♂; *a*. genitalia, lateral, *b*. dorsal, the 8th and 9th sternites omitted, *c*. ventral, *d*. penis-sheaths (?) from above; ♀; *e*. genitalia lateral, *f*. ventral.

Genitalia, ♂. Dorsal margin of the ninth segment with the centre roundly produced and the lateral angles, which are also produced, separated from the centre by rounded excisions; from the side, the upper part of the segment is somewhat quadrate, apical

margin sinuous, lower part long and slender; lying above the produced ventral margin of the eighth segment; intermediate appendages from above, arising from a produced base or perhaps a basal segment withdrawn within the ninth abdominal segment, sinuous, sloping downward, from the side, rather elbowed, with a broad, bifurcate apex; penis most conspicuous; from above, with a constricted stem and broad, heart-shaped apex, slightly excised at the centre of its apical margin and with a projecting spine arising beneath the excision; from the side, bent downward at right-angles, the basal part slender from the side, plate-like from above; the terminal part broader, with the apex dilated on its underside; apical margin truncate, a slender, upcurving spine arising from about the centre; inferior appendages or perhaps the penis-sheaths gimlet-like, apparently three-segmented, terminal segments forming sickle-shaped hooks; the ventral margin of the eighth segment strongly produced into a long finger, from beneath with the apex slightly excised; the ventral margin of the ninth segment is seen to be bifurcate, the forks long and slender, separated by a rounded excision and appearing one on each side of the produced eighth segment; a stout process to the sixth ventral segment.

Genitalia, ♀. Terminal segment from beneath, rectangular; beyond it are seen two quadrate plates, each with the outer apical angle produced into a slender finger; from the side, the lower part of the terminal segment is produced and there is a long, slender tube within the abdomen; this tube can be traced as far back as the fourth segment and its apex projects beyond the terminal segment in a slender rod; a stout process to the sixth ventral segment.

Length of the anterior wing, ♂, 2.5 mm.

 " " " ♀, 3 mm.

MEXICO : Chiapas, Huixtla, 21.xi.1930 (*A. Dampf*); Escuintla, 11.xi.1930 (*A. Dampf*); Mapastepec, 7.xii.1932 (*A. Dampf*); Saltenango de la Paz, 15.iii.1931 (*A. Dampf*); Guerrero, Cocula, 27.ii.1935 (*A. Dampf*).

Type ♂ (Huixtla) in the collection of the British Museum; paratypes ♂ and ♀ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, from various neighbouring localities.

This species resembles, in the construction of the genitalia, the north American species *P. tenebrosa* and *P. lloydii*, described in 1934, *Trans. R. ent. Soc. Lond.*, 82 : 151. In those species, what I described as the lower penis-cover is evidently the produced lower margin of the ninth ventral segment.

Protoptila resolda sp. n. Fig. 6.

Genitalia, ♂. Dorsal margin of the ninth segment sinuous, forming two wide, rounded projections with a wide, rounded excision between; intermediate appendages (?) from the side, long, directed downward, slightly constricted at the centre, apex slightly dilated and rounded; from above, they are difficult to make out and are shown in the figure as rounded continuations of the margin of the ninth segment; penis slender and rod-like; lower penis-cover trough-shaped, sides turned over and above the penis in flattened plates, a slight constriction before the apex which, from above, is widely truncate; from the side, the cover is deep at the base, lower margin straight and horizontal, upper, rounded and sloping downward; inferior appendages (?) with a wide base beyond which are two segments, the first, from the side, not so broad as the base but broader than the fringed terminal segment which, from the side, is sinuous; from above and beneath, outturned at the apex; ventral margin of the ninth segment showing, from the side, as an upturned spur arising towards the centre of the upper margin of the greatly produced eighth ventral segment; from beneath, the apical margin of the ninth segment is wide with the apical angles produced so that they are visible on each side of the margin of the produced eighth segment; this

segment is broad at the base both from the side and from beneath, with the centre produced into a long finger with a truncate apex as seen from beneath; a pointed process to the sixth ventral segment.

Length of the anterior wing, ♂, 2.75 mm.

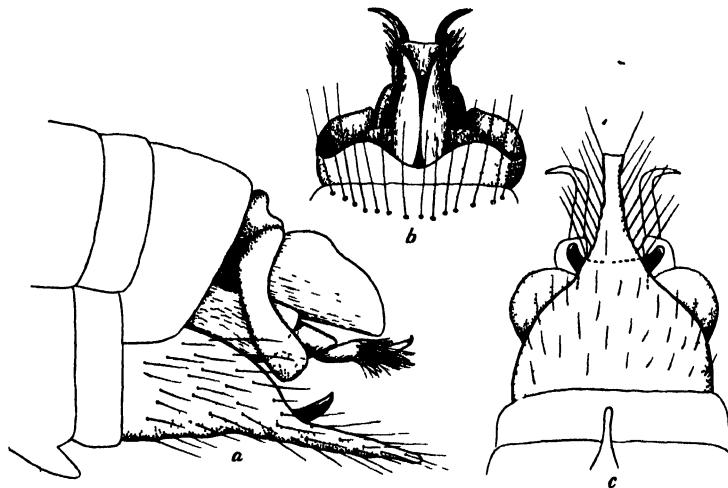


FIG. 6, a-c.—*Protoptila resolda* sp. n. ♂; a. genitalia, lateral, b. dorsal, 8th and 9th sternites omitted, c. ventral.

MEXICO: Chiapas, Dolores, 16.iii.1931 (A. Dampf); Saltenango de la Paz, 15.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum. Paratypes from the same and neighbouring localities, in the British Museum and Dr. G. Ulmer's collection.

Mexitrichia gen. n.

Spurs, 0, 4, 4; antennae about 27-segmented in the ♂; ocelli present; in the anterior wing, there is a pale streak across the anastomosis; the costal margin of the posterior wing is shallowly excised halfway towards the apex; a stout process to the sixth ventral segment in both sexes.

Close to *Mortoniella* but fork no. 5 in the posterior wing is absent and the genitalia differ widely.

Genotype, *Mexitrichia leroda* sp. n.

Mexitrichia leroda sp. n. Fig. 7.

For the general characters, see the generic description.

Genitalia, ♂. Ninth dorsal segment widely excised with a wide, flattened base to the excision; beyond it is jointed a large plate, probably fused superior appendages, with a rounded excision at the apical margin, the outer angles curving inward like a pair of horns; from the side, this plate is wide at the base with a strongly sinuous lower and a serrate upper margin; there is a very long, spine-like upper penis-cover, wider at the base; penis much exserted in the type, fleshy, apex membranous and furnished with a pair of stout, black teeth; sheaths (?) very long and slender, dilated before the apices; lower penis-cover (?)

with two outstanding wings and an asymmetric central spine-like process directed to one side; no inferior appendages; a stout process to the sixth ventral segment.

Genitalia, ♀. There is a dorsal plate with a pair of short, divergent, finger-like processes; from the side, the ventral margin of the ninth segment is produced into a quadrate process; from beneath, the eighth segment is excised at the centre of the apical margin and, in the

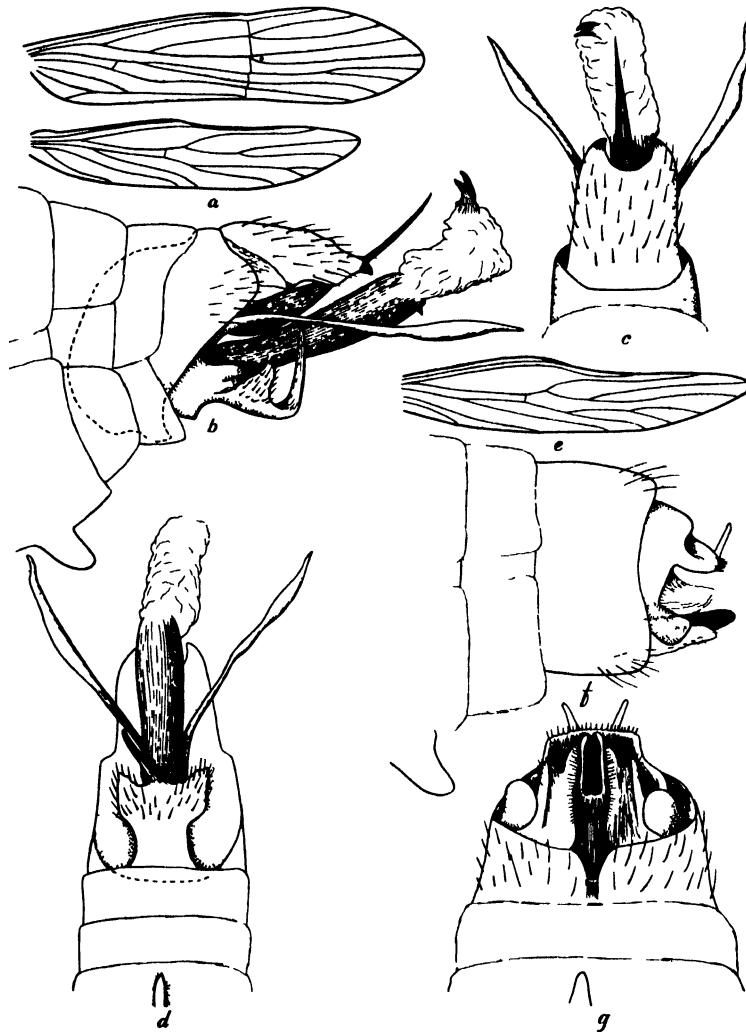


FIG. 7, a-g.—*Mexitrichia leroda* sp. n. ♂; a. wings, b. genitalia, lateral, c. dorsal, d. ventral; ♀, e. posterior wing, f. genitalia, lateral, g. ventral.

centre of the excision, arises a tongue-like process with the centre of the apical part very deep black; there is a round process towards each lateral margin and a pair of plates with apices deeply excised, between them and the central tongue; a stout process to the sixth ventral segment.

Length of anterior wing, ♂ 2.6 mm., ♀ 2.75 mm.

MEXICO: Chiapas, Barranca Honda, 24.ii.1931; Saltenango de la Paz, 15.iii.1931 (*A. Dampf*); Dolores, 16.iii.1931 (*A. Dampf*); San Antonio, Nexapa, 20.xi.1931 (*A. Dampf*); La Suiza, 5.iii.1931 (*A. Dampf*); La Prusia, 25.iii.1931 (*A. Dampf*).

Type ♂ in the collection of the British Museum; other paratypes ♂ from various localities in the neighbourhood, in the British Museum and the collection of Dr. G. G. Ulmer of Hamburg.

In the ♀, the posterior wing differs slightly in neuration from that of the ♂. It is not, however, impossible that the example under observation may be aberrant or that neuration in the genus may vary in individuals.



FIG. 8, a-d.—*Hydroptila mexicana* sp. n. ♂; a. wings, b. genitalia, lateral, c. dorsal, d. ventral.

Hydroptila mexicana sp. n. Fig. 8.

H. mexicana is a well-defined *Hydroptila* belonging to the *sparsa* group, but, apparently, with no scent-organ beneath the scent-organ caps, which are not particularly large or prominent.

Unfortunately, the examples of the species, taken in a light-trap, are not in a condition for parts other than the genitalia to be described.

Genitalia, ♂. Centre of the margin of the terminal dorsal segment slightly produced; dorsal plate as usual in the group, large, excised at its apex with rounded apical angles, rather broad from the side; side-pieces rather long; penis with a very wide, curled hook about midway and a fine, subsidiary branch extending from the left of the lower penis-cover seen from beneath; lower penis-cover very large, apical margin rounded, with a pair of bristles towards the centre below the apical margin; inferior appendages very large, with wide, truncated and blackened apical margins; from above and below, they are rather widely divergent; a short, stout process to the seventh ventral segment.

Length of anterior wing, ♂, 2.5 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (A. Dampf).

Type and paratypes ♂ in the collection of the British Museum. Other paratypes in the collection of Dr. G. Ulmer, Hamburg, from the same or neighbouring localities.

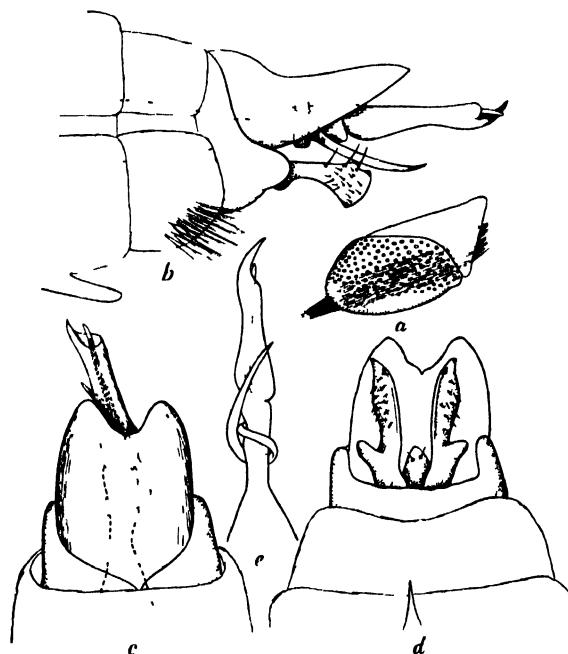


FIG. 9, a-e.—*Hydroptila icona* sp. n. ♂; a. scent-organ cap with eversible filament, b. genitalia, lateral, c. dorsal, d. ventral, e. penis.

Hydroptila icona sp. n. Fig. 9.

Antennae about 30-segmented in the ♂, some of the segments being white, others black, the three terminal segments white; scent-organ caps long and narrow; scent-organ consisting of a pair of eversible filaments clothed with fine hairs; wings conforming to the usual pattern in *Hydroptila*.

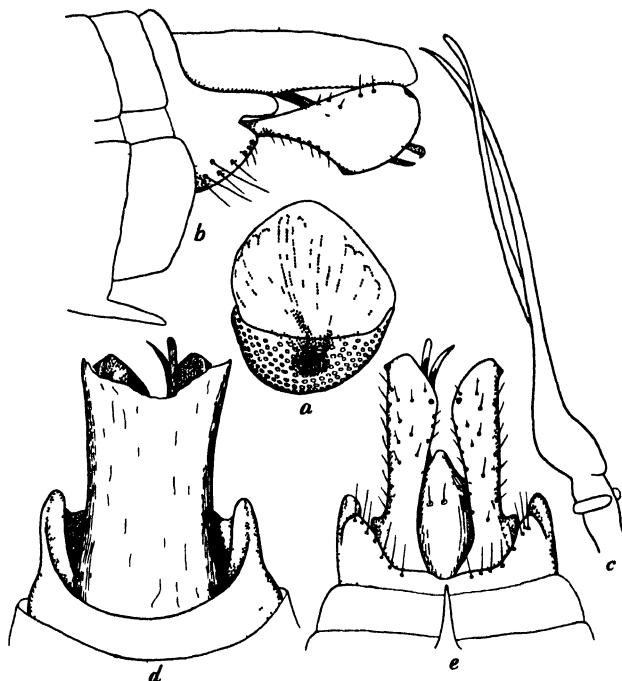
Genitalia, ♂. Dorsal plate very large, apical margin forming two rounded lobes with a wide excision between; penis unusually stout with a sheath partly curled round the stem, leaving the apical part free and, as seen from the side, slightly curved beneath the penis; the penis itself is sleeve-like with one side of the apex produced into a pointed process and

with a central tube projecting beyond it; lower penis-cover very transparent, conical, with two bristles near the apex; side-pieces of the ninth segment broad and rounded; inferior appendages from the side, with dilated, clavate apices which bear black spots at the lower and upper angles; a row of stiff spines along the upper margin; from beneath, the lateral margins are produced towards the base in short processes with rounded apices; the margin of the ninth ventral segment is deeply and widely excised; a short, pointed process to the seventh ventral segment.

Length of the anterior wing, ♂, 2 mm.

MEXICO: Chiapas, Dolores, 16.iii.1931; Saltenango de la Paz, 15.iii.1931; Sinaloa, Badiraguata, 30.iii.1932 (all *A. Dampf*).

Type ♂ in the collection of the British Museum; paratypes from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.



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FIG. 10, a-e.—*Hydroptila meralda* sp. n. ♂; a. scent-organ cap with scent-hairs, b. genitalia, lateral, c. penis, d. genitalia, dorsal, e. ventral.

***Hydroptila meralda* sp. n. Fig. 10.**

Antenna with about 35 segments; scent-organ cap acorn-shaped with the cap considerably smaller than the acorn, scent-hairs very broad, possibly attached to an eversible filament; the caps seem peculiarly attached, with the upper margins caught in a fold so that they lie very close to the head and, in the example under examination, cannot be lifted for inspection of the hairs underneath.

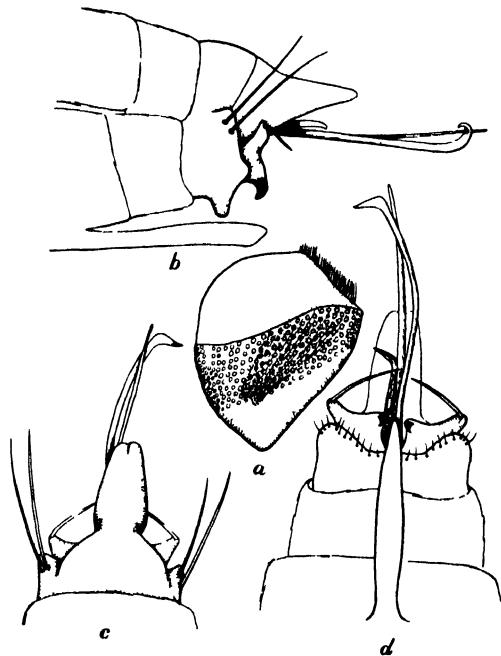
Genitalia, ♂. Dorsal plate with the apical margin widely excised (somewhat torn in the type); no lateral, angular dilatations at the base; side-pieces of the ninth segment rounded;

penis forming two long, slender spines with no right-angled hook as is found in many of the *Hydroptila* species; lower penis-cover very broad at the base, apex acute and produced, two short spines arising at the centre and towards the apex; inferior appendage from the side, with a slender stem and much dilated apex and with two black warts at the upper and lower apical angles; from beneath, the upper of these warts forms a distinct angular projection; margin of the ninth segment concave from above, concave and sinuous from beneath; a long, pointed process to the seventh ventral segment.

Length of the anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Esmeralda, 19.xi.1930 (A. Dampf).

Type ♂ in the collection of the British Museum. Other paratypes from the same or neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.



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FIG. 11, a-d.—*Hydroptila modica* sp. n. ♂; a. scent-organ cap with scent-hairs, b. genitalia, lateral, c. dorsal, d. ventral.

Hydroptila modica sp. n. Fig. 11.

Scent-organ caps of the usual "cup and acorn" pattern but with the "cup" unusually wide and somewhat produced on the inner edge; beneath the caps is a pair of eversible filaments clothed with dark hairs; wings of the usual *Hydroptila* pattern.

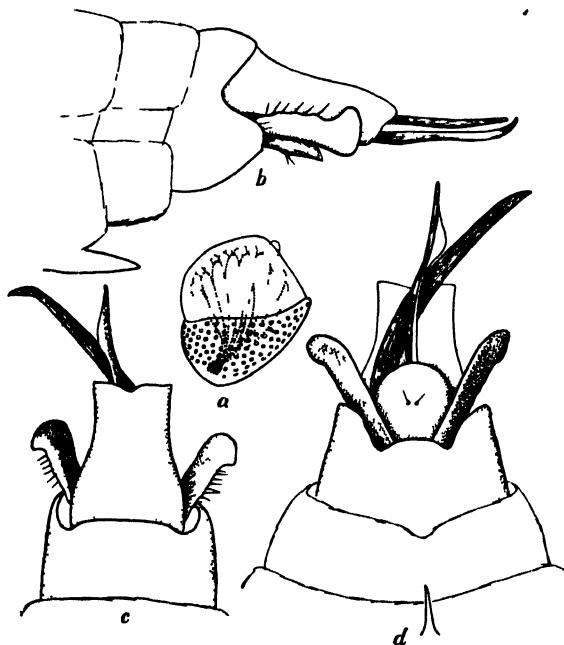
Genitalia, ♂. Ninth dorsal segment produced and rounded; beyond it is a boat-shaped plate as in the European species *femoralis*, apex excised; beneath this plate extends the penis and sheath, both long and spine-like; apex of the penis bent at right-angles; a single broad sheath visible at a point midway under the dorsal plate, apex turned to one side at a wide angle; inferior appendages very broad, inner angles close together forming blackened hooks directed downwards, outer angles produced outwardly and upwardly as seen from beneath, each armed with a long, transparent spine, directed nearly horizontally over the

appendage; margin of the ninth ventral segment widely excised; a long, stout process to the seventh ventral segment extending as far as the apices of the inferior appendages.

Length of the anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931; Saltenango de la Paz, 15.iii.1931 (*A. Dampf*).

Type ♂ in the collection of the British Museum. Other paratypes in the British Museum and the collection of Dr. G. Ulmer from the same and neighbouring localities.



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FIG. 12, *a-d.*—*Hydroptila paschia* sp. n. ♂; *a.* scent-organ cap with scent-hairs, *b.* genitalia, lateral, *c.* dorsal, *d.* ventral.

Hydroptila paschia sp. n. Fig. 12.

Antenna about 37-segmented; scent-organ consisting of dense masses of broad scale-like hairs lining the caps which are of the typical form in *Hydroptila*; wings as in *mexicana*.

Genitalia, ♂. Ninth dorsal segment produced in the centre of its apical margin; dorsal plate long, broad at the base, narrowing to a truncate apex which has a somewhat sinuous margin, excised slightly at its centre; penis and single sheath long, and sinuous, sheath rather the longer and crossing the penis towards the apex; no right-angled bend to the penis; there is a lower penis-cover with a rounded apex and two short, stout, projecting spines in the centre of its ventral surface; the inferior appendages widely diverging, with apices slightly dilated and a row of stiff bristles along the upper margin; a short pointed process to the seventh ventral segment.

Length of anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (*A. Dampf*).

Type ♂ and paratypes ♂ in the collection of the British Museum from the

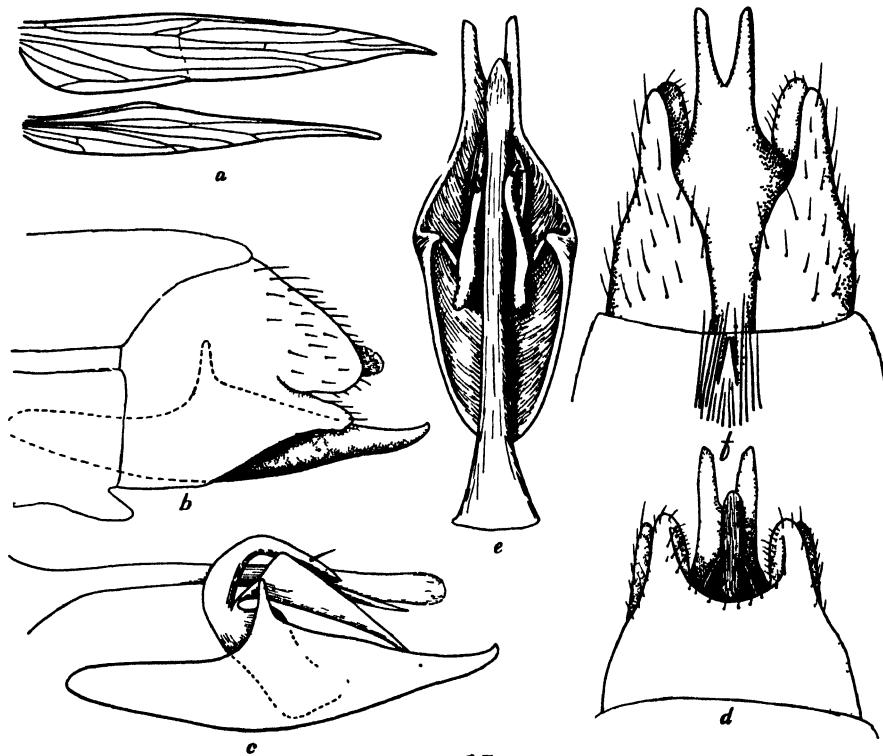
same or neighbouring localities; further paratypes in the collection of Dr. G. Ulmer, of Hamburg.

Loxotrichia gen. n.

Spurs, 0, 3, 4; antennae about 29-segmented in the ♂; ocelli present; anterior wing very broad, produced and acuminate at its apex; posterior wing with the costal margin elevated at a point nearly midway, then produced and acuminate.

Ventral margin of the ninth segment produced and bifurcate; a ventral process to the seventh segment.

Genotype, *Loxotrichia azteca* sp. n.



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FIG. 13, *a-f.*—*Loxotrichia azteca* sp. n. ♂; *a*. wings, *b*. genitalia, lateral, *c*. internal structures, the penis, etc., lateral, *d*. genitalia, dorsal, *e*. penis-sheaths and 9th sternite, dorsal, *f*. genitalia, ventral.

***Loxotrichia azteca* sp. n. Fig. 13.**

Antennae with the first seventeen segments white, the next three black, the next one white, the next five black and the last three white.

Genitalia, ♂. The ninth segment is retracted within the eighth with the exception of the produced lower, bifurcate margin; each fork of this margin is long and slender, with a deep excision between; the eighth dorsal segment bears a deep, U-shaped excision at the apical margin and in it may be seen a spatulate-shaped penis; from the side, the margin of the eighth segment is divided by a narrow excision, the upper part, broad and rounded, the lower, narrow; from beneath, the ventral margin of the segment is excised right to

the base so that two processes are formed with wide bases and finger-like apices; these processes are so heavily fringed that they conceal the genitalia from beneath; in a balsam preparation, a complicated, internal structure can be made out consisting of a pair of asymmetric, arching, sinuous sheaths and a lower penis-cover which, from the side, is broad at the base and tapers to an acute and downwardly directed apex; a slender spine may be seen beneath the penis, varying in length in individuals; there is a short, pointed ventral process to the seventh segment.

Length of the anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931; Santa Ana, 25.ii.1931; La Suiza, 7.iii.1931; La Prusia, 25.iii.1931; Saltenango de la Paz, 15.iii.1931 (all *A. Dampf*).

Type ♂ in the collection of the British Museum; paratypes ♂ and ♀ from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.

Loxotrichia dalmeria sp. n. Fig. 14.

Wings as in *L. azteca*.

Genitalia, ♂. Dorsal margin of the eighth segment widely excised. There may possibly be a membranous plate, but this is doubtful in the example under observation. The ninth segment is only visible from below and from the side and the position of its upper margin is doubtful. In the excision of the eighth segment, from above, may be seen two very strongly chitinised black spines, the apices of which are bent inwards at right angles, the bent apices lying one above the other, but this position varies in different individuals; penis long with a sinuous spur towards the membranous, inflated apex; from the side, below the penis, may be seen a structure, either the lower penis-cover or possibly pertaining to the upper part of the ninth segment; the lower margin of the ninth segment is produced and bifurcate but with the forks much shorter than in *azteca*, and from the side, directed slightly upward; there is a second bifurcate process lying closely above the forks of this segment, the apices just visible from beneath and from the side; each fork of the ninth segment is reinforced beneath with a strong ridge; the margin of the eighth sternite is widely excised, the excision extending to the anterior margin of the seventh segment, which carries a stout process concealed in a dense mat of hairs.

Length of the anterior wing, ♂, 2 mm.

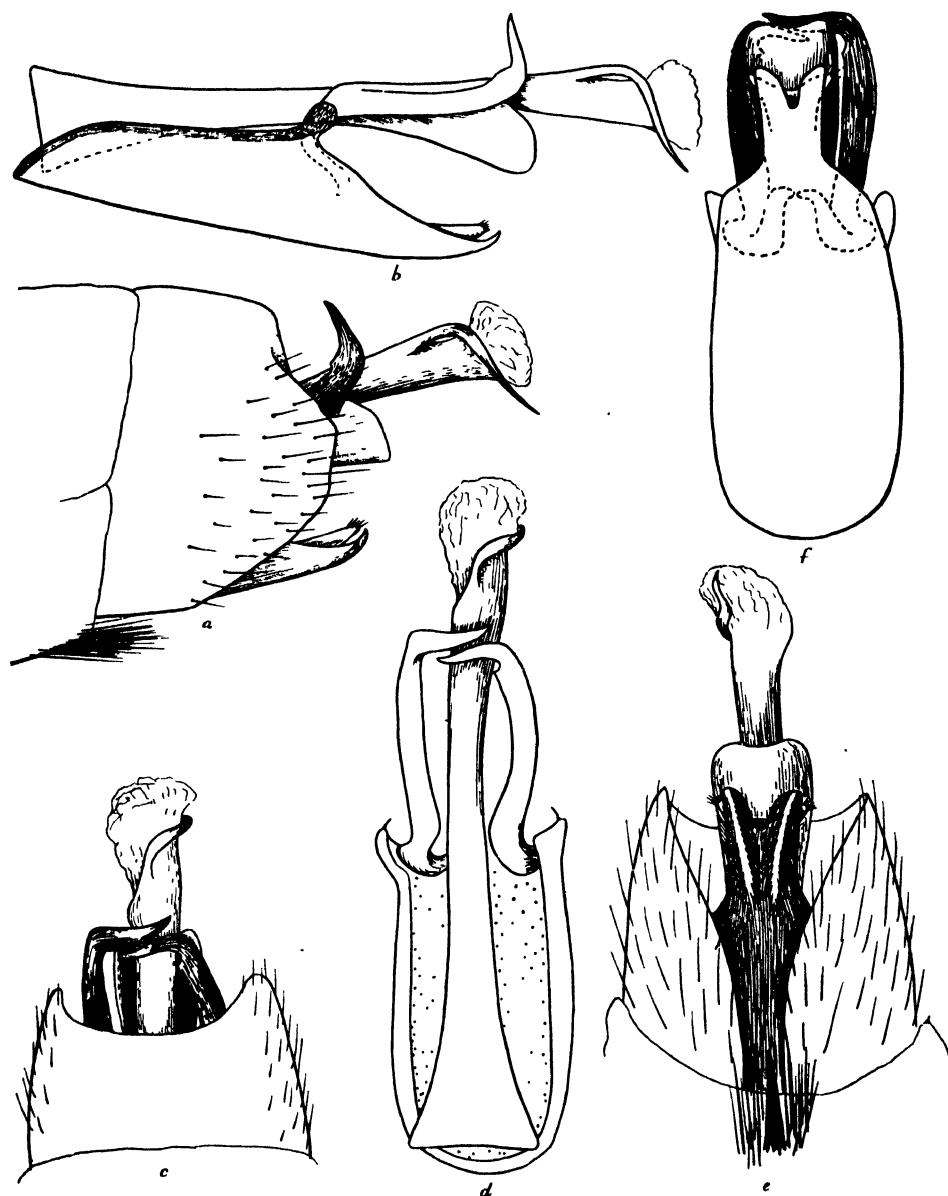
MEXICO : Chiapas, Esmeralda, 19.xi.1930 (*A. Dampf*).

Type ♂ in the collection of the British Museum. Other paratypes from the same and neighbouring localities, in the collection of the British Museum and of Dr. G. Ulmer.

Costatrichia gen. n.

Spurs, 1, 3, 4. Ocelli present; antennae clothed with much broadened hairs, 19-segmented; basal segment long and broad, second cup-shaped, next six short, very broad and flattened, the remaining segments normal in character to the apex so that the antenna resembles the backbone of a vertebrate animal; maxillary palpi, the two basal segments short, third long, fourth short, fifth longer than the third; anterior wing with a long cylindrical structure on the costa near the base; in a balsam preparation, this structure is seen to be a pocket filled with long hairs; neuration difficult to make out; in the anterior wing there is apparently a kind of central rib which gives the neuration a resemblance to the veining of a narrow leaf; the fifth ventral segment carries a pair of small warts bearing tufts of hairs. It should be mentioned, however, that this or homologous structures occur in many other genera of the HYDROPTILIDAE.

Genotype, *Costatrichia lodora* sp. n.

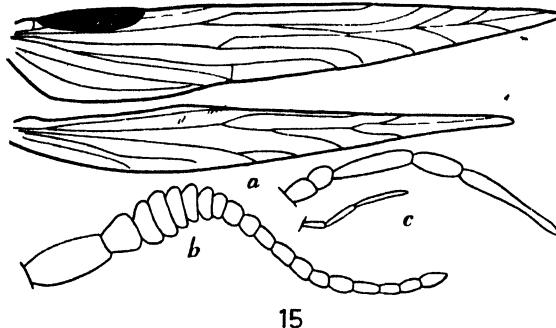


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FIG. 14, *a-f.*—*Loxotrichia dalmeria* sp. n. ♂; *a.* genitalia, lateral, *b.* internal structure, lateral, *c.* genitalia, dorsal, *d.* internal structure, dorsal, *e.* genitalia, ventral, dorsal spines omitted, *f.* internal structures, etc., ventral.

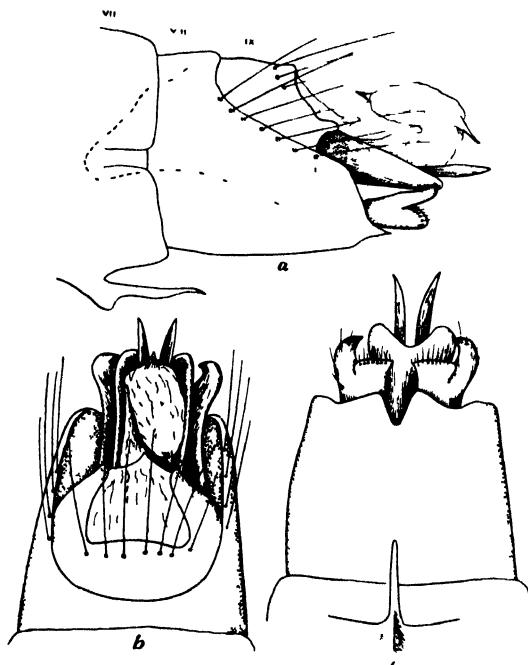
Costatrichia lodora sp. n. Figs. 15 and 16.

To the description already given under the generic characters may be added that the eighth segment as well as the ninth is of the strongly chitinised capsule pattern.



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FIG. 15, *a-c.*—*Costatrichia lodora* sp. n. ♂; *a.* wings, *b.* antenna, *c.* maxillary and labial palpi.



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FIG. 16, *a-c.*—*Costatrichia lodora* sp. n. ♂; *a.* genitalia, lateral, *b.* dorsal, *c.* ventral.

Genitalia, ♂. Lower half of the eighth segment produced considerably beyond the upper, with the sides bearing a few unusually long, stiff hairs; dorsal margin of the segment widely excised; the ninth segment appears in the excision, also widely excised and with a membranous dorsal plate which bears a minute projection at the centre of its apical

margin; at each angle of the excision of the ninth segment is a short process projecting tailwards; penis large and broad with a membranous apex folded back and armed at its tip and at the bend with single transparent spines; beneath it is a pair of long sheaths; there is a long and broad lower penis-cover with an excised apex; inferior appendages two-branched, inner branches with broad truncate apices; outside and above these, the second branches are rather broad, narrowing to hook-like apices directed inwards; the eighth ventral segment bears on its apical margin two triangular projections with a deep V-shaped excision between; a long process with a stout keel-like base and produced apical part arises from the seventh ventral segment.

Length of anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (A. Dampf).

Type ♂ and paratypes ♂ in the collection of the British Museum; other paratypes ♂ in the collection of Dr. G. Ulmer, Hamburg, from the same or neighbouring localities.

Dampfitrichia gen. n.

Spurs, 0, 3, 4; ocelli present; two large "caps" at the back of the head but no scent-organ beneath them; wings very long, apices produced and acuminate; costal margin of the posterior slightly elevated towards its base.

Other characters are given in the specific description.

Genotype, *Dampfitrichia ulmeri* sp. n.

Dampfitrichia ulmeri sp. n. Fig. 17.

Anterior wing light ochraceous, tip black; two conspicuous dark patches on the costal fringe, one from the base to about half-way, the other nearer the base.

Genitalia, ♂. Ninth segment almost entirely withdrawn within the eighth; dorsal margin of the eighth widely excised almost to the base, apical angles produced in slender fingers which, from the side, arise from broad, triangular bases; in the centre of the excision, through a transparent and rounded dorsal plate may be seen the penis which protrudes from a sleeve which reaches to about half-way up the visible portion; terminal part slender with the apex curled round at right-angles; beneath the penis is a strongly chitinised plate, which, seen from above, has a widely excised apical margin and produced apical angles; on each side of this plate is a pair of small, rounded processes, the outer armed with a pair of stout bristles, the inner with only one; there is also a large, triangular plate with an acute apex as seen from above and beneath, curving upward from the side; this is the ventral margin of the ninth segment; eighth ventral segment widely and roundly excised, the apical angles slightly produced; no ventral process.

Length of the anterior wing, ♂ and ♀, 1.75 mm.

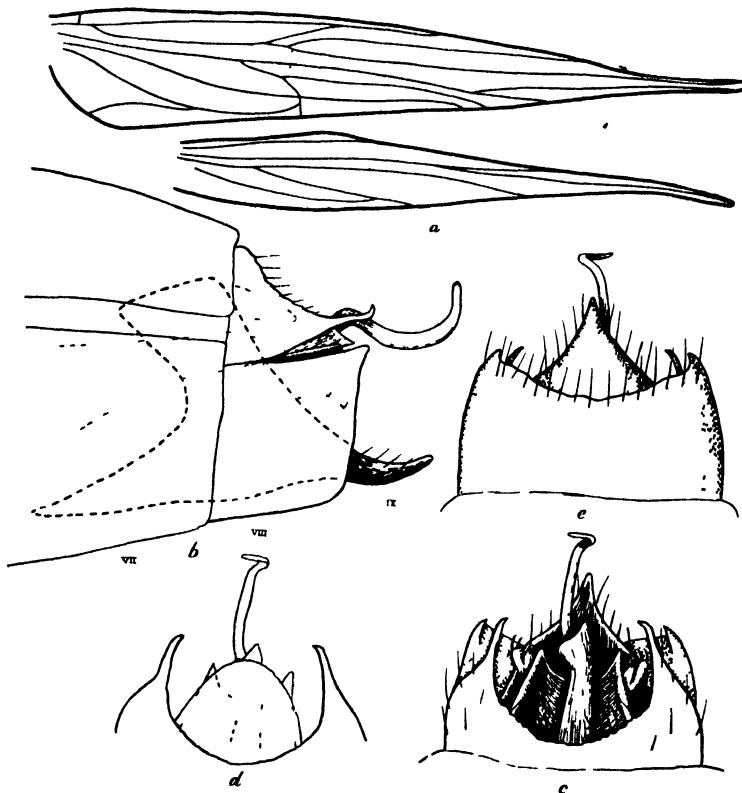
MEXICO : Chiapas, Dolores, 16.iii.1931 (A. Dampf); Saltenango de la Paz, 15.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum; paratypes ♂ and ♀ from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.

I have pleasure in dedicating this genus to Dr. A. Dampf, whose collection of Mexican HYDROPTILIDAE far exceeds in numbers and value any others made in the whole of the American continent. I dedicate the species to our mutual friend, Dr. G. Ulmer, at whose invitation I have been enabled to work out the collection.

Exitrichia gen. n.

Spurs, 0, 2, 3; antennae about 18-segmented in the ♂; ocelli present; side-pieces of the ninth segment produced and usually, but not always, with clavate apices as seen from the



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FIG. 17, a-e.—*Dampftrichia ulmeri* sp. n. ♂; a. wings, b. genitalia, lateral, c. dorsal, dorsal plate omitted, d. dorsal plate, etc., e. genitalia, ventral.

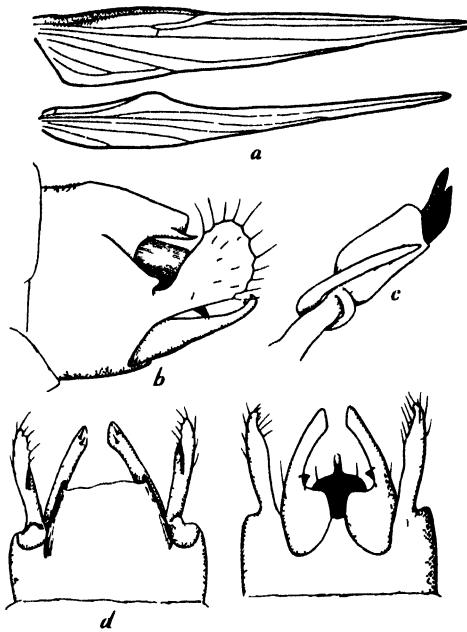
side; no ventral process; anterior wing rather short, with the costal area apparently somewhat thickened towards the base, neuration very simple and incomplete.

Genotype, *Exitrichia anahua* sp. n.

Exitrichia anahua sp. n. Fig. 18.

Genitalia, ♂. Apical margin of the ninth dorsal segment produced into a square, membranous plate, with the sides strongly chitinised and the apical angles slightly produced; from the side, these apical angles appear as distinct and slightly curved processes with rather broad bases and acute apices; from above, there is a punctate patch towards the basal margin of the segment; penis retracted in the example under description and terminating in two blackened claws and with the usual tube curled round the stem below the apex; side-pieces of the ninth segment with constricted stems and enormously

dilated apices, apical margins serrate; in a balsam preparation, from beneath, there can be seen a pair of intermediate appendages (?) terminating in somewhat truncate apices with produced inner angles, downturned as seen from the side; there is a lower penis-cover in the form of a broad plate with the apical margin produced at the centre in a long, downwardly directed finger; inferior appendages from beneath, arise from broad bases and are cut away on their inner margins nearly at right-angles, leaving slender,



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FIG. 18, *a-e.*—*Exitrichia anahua* sp. n. ♂; *a.* wings, *b.* genitalia, lateral, *c.* penis, *d.* genitalia, dorsal, *e.* ventral.

slightly incurving terminations with obliquely truncate apices, each armed with a pair of short bristles on its upper surface just short of the apical margin; ninth ventral segment produced at the centre of its apical margin into a triangular process with a truncate apex bearing a minute excision at the centre.

Length of the anterior wing, ♂, 1.25 mm.

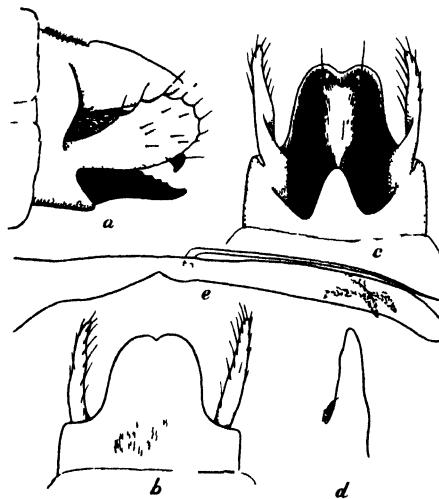
MEXICO: Chiapas, Dolores, 16.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum; other paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, all from the same or neighbouring localities.

Exitrichia digitata sp. n. Fig. 19.

Genitalia, ♂. Dorsal margin of the ninth segment produced into a large, rounded plate with a small excision at the centre of its rounded apical margin; side-pieces of the segment large, lower margin convex, apices dilated and outer margins serrate, sparsely fringed with long hairs; lower penis-cover (?) from beneath, with a widely excised apical margin, apical angles each bearing a single bristle and appearing as a pair of downturned hooks; seen from the side, there is a thin, upper, projecting shelf and a short, finger-like process on each side of the cover, appearing as a small triangular projection on the basal margin;

penis long and slender, apex rounded, with a pair of blackened claws in a membranous sheath; a long, thin tube arises midway and runs parallel with the main stem; inferior appendages from beneath, appear as two large, blackened fingers, each with an upper, claw-shaped branch towards the centre, directed outwards; these branches are only visible in cleared examples; from the side, the lower margin of the appendage is sinuous, upper,



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FIG. 19, a-e.—*Exitrichia digitata* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. an inferior appendage, ventral, e. penis.

strongly serrate; ventral margin of the ninth segment produced at its centre into a strong, triangular process.

Length of the anterior wing, ♂, 1.25 mm.

MEXICO: Guerrero, Cocula, 27.ii.1935 (A. Dampf).

Type ♂ in the collection of the British Museum; paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, all from the same or neighbouring localities.

Exitrichia eroga sp. n. Fig. 20.

Genitalia, ♂. Apical margin of the ninth segment produced into a pair of rounded lobes with a small, wide excision between; side-pieces of the ninth segment very large, from the side, much dilated at the apices on the upper sides; from above, the stems are slender, expanding inwards towards the apices so that the inner margins are bent at obtuse angles; the apices are thus very broad with obliquely truncate margins; penis long and slender, with an external tube arising from about the centre, apex possibly wanting in the example under description as the usual blackened hooks or spurs are not visible; lower penis-cover broad, apical margin truncate, bearing two widely separated warts, each armed with a single bristle; inferior appendages long, as seen from beneath, arising from wide bases, inner margins cut away at right-angles about midway, leaving slender, parallel terminations with a deep U-shaped excision between; each appendage carries a small, black upper branch lying close above the broad base; ninth ventral segment excised,

with an approximately hexagonal, unpigmented area, upper side excised, situated above the excision.

Length of the anterior wing, ♂, 1.5 mm.

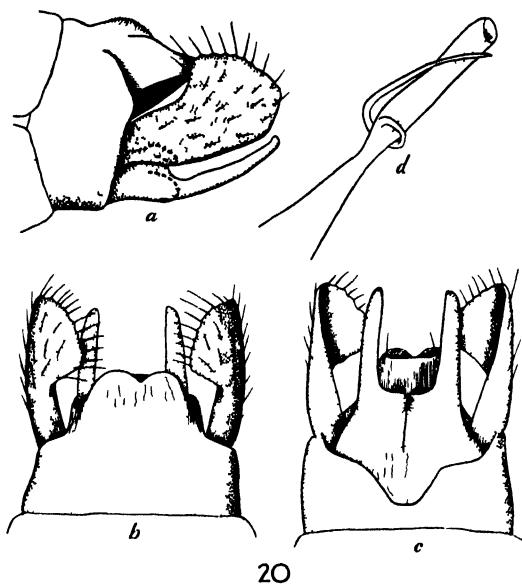


FIG. 20, *a-d.*—*Exitrichia erga* sp. n. ♂; *a.* genitalia, lateral, *b.* dorsal, *c.* ventral, *d.* penis.

MEXICO: Guerrero, Cocula, 27.ii.1935 (A. Dampf).

Type ♂ in the collection of the British Museum; paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, from the same or neighbouring localities.

Exitrichia esmalda sp. n. Fig. 21.

The example of this species under description is slightly damaged, the dorsal margin of both eighth and ninth segments being torn.

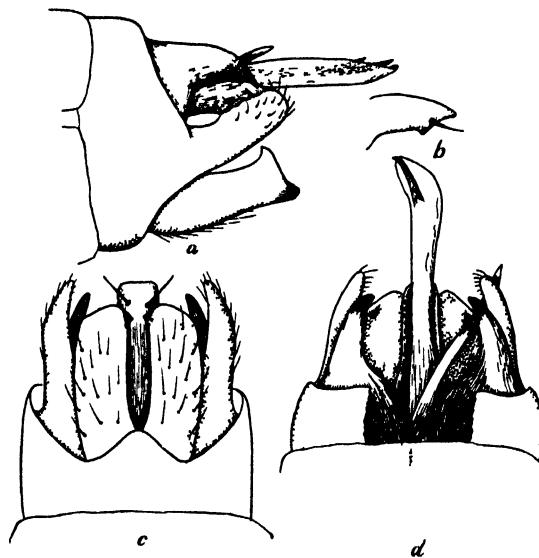
Genitalia, ♂. From above, there are two strongly chitinised, stout processes with blackened, slightly incurving, acute apices; between them is a long penis, apex furnished with a rather long spine, a branch arising towards the base and lying across the genitalia; side-pieces of the ninth segment from above, slightly longer than the upper processes; from the side, rather long and narrow, upper margin carrying some short bristles; lower penis-cover about the same length as the side-pieces, apex truncate and furnished beneath with a pair of diverging bristles; inferior appendages very stout, from the side, with a truncate apex, lower apical angle blackened, the upper produced into a short, acute hook; from beneath, the bases approximate, the inner margins diverging slightly to the truncate apices; inner apical angles blackened and produced slightly inward; margin of the ninth ventral segment produced at its centre into a triangular process.

Length of the anterior wing, ♂, 1.5 mm.

MEXICO: Chiapas, Esmeralda, 19.xi.1930 (A. Dampf).

Type ♂ in the collection of the British Museum. Other paratypes, from the

same and neighbouring localities, in the collection of the British Museum and of Dr. G. Ulmer.



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FIG. 21, *a-d.*—*Extrichia esmalda* sp. n. ♂; *a*. genitalia, lateral, *b*. apex of the lower penis-cover, lateral, *c*. genitalia ventral, *d*. dorsal.

Extrichia exicoma sp. n. Fig. 22.

Genitalia, ♂. Margin of the ninth dorsal segment produced into a large plate slightly excised at the centre of its apical margin; towards the base of the segment is a patch of



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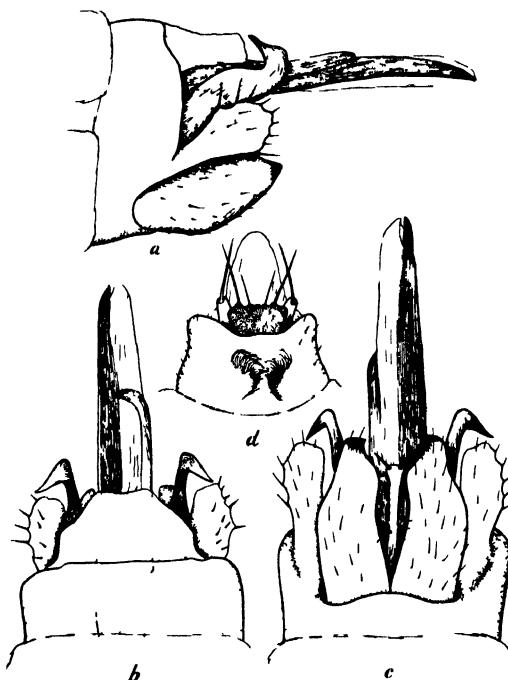
FIG. 22, *a-d.*—*Extrichia exicoma* sp. n. ♂; *a*. genitalia, lateral, *b*. dorsal, *c*. ventral, *d*. penis.

short, fine hairs; side-pieces of the ninth segment are fringed with wide-spread hairs and extend not quite so far as the apex of the dorsal plate; they appear slightly elbowed from above; from the side, margins serrate, apex slightly narrower than the base; beneath the dorsal plate is a large lower penis-cover (?) roughly pear-shaped from the side; from beneath, very broad at the base with two divergent finger-like ridges beneath the apex, each armed with a stout outwardly-directed spine; in the figure, the cover is slightly raised out of place; there are two intermediate appendages (?), stout and clavate from the side; from beneath, apices having the appearance of birds' heads, beaks directed towards each other; penis long, apex spatulate, a single slender spine arising midway, directed to one side; inferior appendages from beneath, stout and incurving, each with its apical margin rectangularly excised; a supplementary plate behind each towards its inner margin; from the side, irregular in shape.

Length of the anterior wing, ♂, 1.5 mm.

MEXICO: Chiapas, Dolores, 16.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum; other paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, all from the same or neighbouring localities.



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FIG. 23, a-d.—*Exitrichia olorina* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. genitalia ♀, ventral.

Exitrichia olorina sp. n. Fig. 23.

Wings ochraceous with little horizontal streaks of fuscous hairs scattered along the length of the anterior.

Genitalia, ♂. Apical margin of the ninth dorsal segment slightly produced and truncate; beyond it is a broad dorsal plate of nearly the full width of the ninth segment at its base.

narrowing somewhat to a broad and slightly concave apex; beneath the plate is a pair of appendages, possibly the intermediate ones, with apices resembling swans' heads, beaks directed upwards and outwards; penis very long, with two asymmetric sheaths, the one extending the entire length and the other to about midway with the apex hook-like and turned inward; in a balsam preparation a third hook or tube may be seen, towards the base, directed to one side; lower penis-cover very broad with a deep, ventral keel furnished at the apex with a pair of divergent bristles; side-pieces of the ninth segment very large, stems slender, apices clavate with upper and apical margins serrate; inferior appendages from the side and also from beneath, broad and long; from beneath, with sinuous inner and outer margins, apices broadly hooked, and directed inward; there is a hooked process towards the centre of each appendage on its inner surface, directed inwards; ventral margin of the ninth segment widely excised, with the base of the excision slightly produced and rounded.

Genitalia, ♀. From above, the terminal segment is produced into a narrow, ovate plate; from beneath, at the base of this plate, is a strongly chitinised lobe, narrower at the base than at the truncate and serrate apex which is set with two long outer and two shorter inner bristles; on each side of this lobe is a membranous finger terminating in a long bristle; the ventral segment below is sinuously concave at its apex and bears on its surface, towards the centre, a strongly chitinised structure with a wide, excised apex and slender stem.

Length of anterior wing, ♂ 1.75 mm., ♀ 1.5 mm.

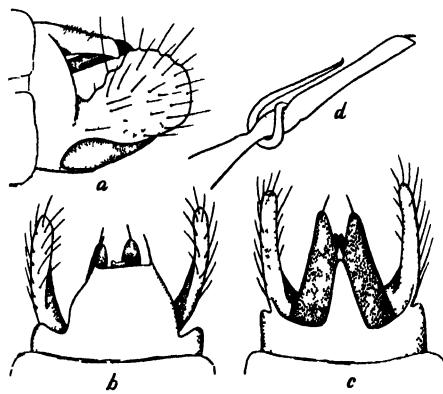
MEXICO: Guerrero, Cocula, 27.ii.1935 (A. Dampf).

Type ♂ in the collection of the British Museum; other paratypes ♂ and ♀ from the same and neighbouring localities in the British Museum and the collection of Dr. G. Ulmer, of Hamburg.

Extrichia oxima sp. n. Fig. 24.

Wings dark fuscous; insects particularly small.

Genitalia, ♂. Ninth dorsal segment produced in a broad plate with a broad, punctate, fuscous patch in the basal half and a broad, truncate apex with each apical angle furnished



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FIG. 24, a-d.—*Extrichia oxima* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. penis.

with a stout, slightly incurved bristle; there are two projecting angles at the base, as seen from above; penis straight with the usual tube curved round the centre and continuing from there midway to the apex parallel with the stem; side-pieces of the ninth segment with constricted stems and enormously dilated apices, upper margins serrate; inferior appendages from beneath, forming two blackened, finger-like, tapering processes, each with

an upper branch which, from the side, can only be seen in a balsam preparation; from beneath, the ninth ventral segment appears to be produced in a long, narrow, triangular process which, however, is somewhat obscure.

Length of anterior wing, ♂, 1.25 mm.

MEXICO: Guerrero, Cocula, 27.ii.1935 (A. Dampf).

Type ♂ in the collection of the British Museum; other paratypes from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer, of Hamburg.

Dolotrichia gen. n.

Spurs, 0, 2, 3; ocelli present; anterior wing short, tapering gradually to an acute apex; posterior, with the costal margin much elevated towards its base, after which it is very narrow and pointed; in the ♂, there is a large dorsal plate, the apical angles of which are produced into large, inturned and strongly chitinised hooks; no ventral process.

The genus belongs to the *Exitrichia* group, from which it may be readily distinguished by the peculiar dorsal plate of the ♂ genitalia.

Genotype, *Dolotrichia canixa* sp. n.

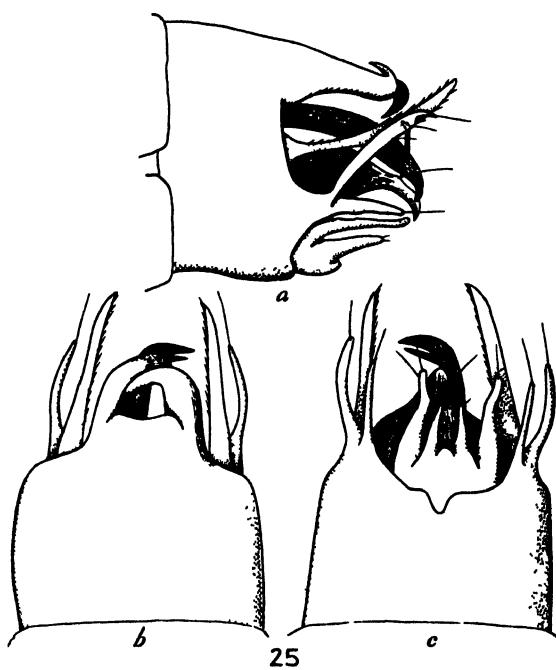


FIG. 25, a-c.—*Dolotrichia canixa* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral.

Dolotrichia canixa sp. n. Fig. 25.

Genitalia, ♂. Ninth segment produced into a large dorsal plate with a broad apex; at the apical angles is a pair of broad, asymmetric hooks, the one turning downward and the other upward; on each side of the plate is a long, slender intermediate (?) appendage with a strongly fringed inner margin; each side-piece of the ninth segment is produced into a pair of slender rods of which the upper, as seen from the side, is the longer and termin-

ates in a rather more slender finger; the upper is directed upwards and tailwards, the lower tailwards so that there is an acute-angled excision between them; from beneath, the upper appears outside the lower; beneath the dorsal plate, from above, is a large, black penis, the apex bent to one side nearly at right-angles, with a small, black branch arising towards the upper surface, directed to one side and upward so that, from above, and beneath, the apex appears bifurcate; lower penis-cover, from beneath, very broad with an acute, cone-shaped apex, bearing a pair of long, widely divergent bristles on its upper surface; inferior appendages from beneath, bifurcate, the outer fork slightly longer than the inner, both forks slender and sinuous; the appendages are fused together with a small, rounded lobe between them at their bases; margin of the ninth ventral segment excised at its centre.

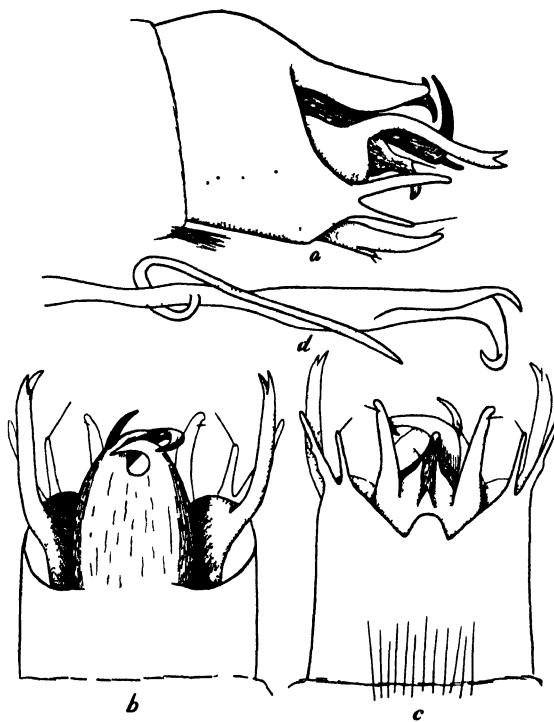
Length of the anterior wing, ♂, 1.5 mm.

MEXICO: Chiapas, Dolores, 16.iii.1931 (*A. Dampf*).

Type ♂ in the collection of the British Museum.

Dolotrichia xicana sp. n. Fig. 26.

Maxillary palpi wanting and all the antennae excepting the two basal segments; there are two median-sized, rather wide scent-organ caps at the back of the head but no scent-



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FIG. 26, a-d.—*Dolotrichia xicana* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. penis.

organ beneath them; a black, raised line at the vertex; ocelli present; legs much broken but spurs probably 0, 2, 3.

Genitalia, ♂. Ninth segment produced into a large dorsal plate which terminates at the apex in two large, inturned, asymmetric hooks; on each side is a long, sinuous inter-

mediate (?) appendage with a forked apex arising from a broad base; penis black with a black, spine-like lower sheath and a second, curling at right-angles towards the spine-like apex; each side-piece of the ninth segment is produced into a pair of divergent, rod-like processes, as seen from the side, the upper the longer; lower penis-cover forming a broad triangular plate with a downturned, hook-like apex; inferior appendages from beneath, bifurcate, outer forks about twice the length of the inner; a small triangular projection joining the bases of the appendages; margin of the ninth ventral segment widely excised with the centre of the excision produced in a rather broad, rounded lobe.

Length of anterior wing, ♂, 1.5 mm.

MEXICO: Chiapas, Dolores, 16.iii.1931 (A. Dampf); Barranca Honda, 24.ii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum. Other paratypes in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, from various neighbouring localities.

Guerrotrichia gen. n.

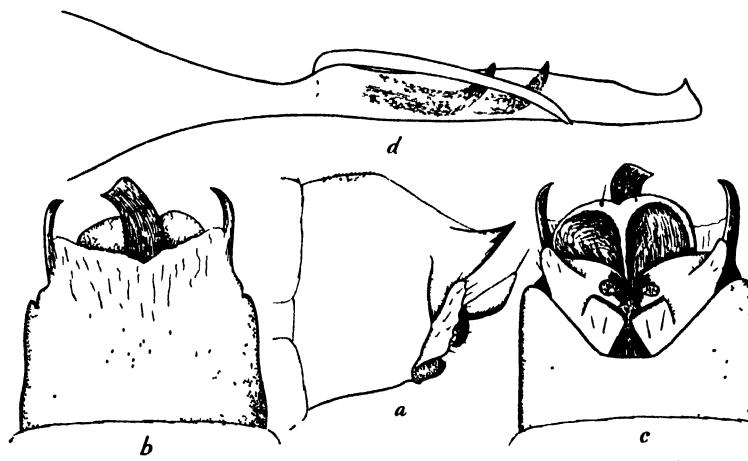
Spurs, 0, 2, 3; ocelli present; the side-pieces of the ninth segment wanting. Wings as in *Exitrichia*.

In all other respects, the genus closely resembles *Exitrichia*.

Genotype, *Guerrotrichia caxima* sp. n.

Guerrotrichia caxima sp. n. Fig. 27.

Genitalia, ♂. Margin of the ninth dorsal segment membranous, widely excised, somewhat shrunken in the example under description, apical angles produced into slender,



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FIG. 27, a-d.—*Guerrotrichia caxima* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. penis.

incurving, horn-like processes from above and beneath; from the side, they are triangular with broad bases; penis terminating in an obliquely truncate apex with a small, lateral beak; two stout, black spurs may be seen within the main stem about midway, and nearer the base, there arises a slender, external tube, apex extending slightly beyond these spurs; the base of the penis is unusually wide; lower penis-cover broad, supported from beneath by a Y-shaped, strongly chitinised structure, apical margin rounded and slightly excised at

its centre; inferior appendages probably four-branched; from beneath, the upper branches form curved, inturned hooks with downwardly directed, blackened apices; the next branches arise from wide bases and are triangular and widely divergent, from the side, slender, directed upward and bearing a few scattered hairs; the third branches are short and rectangular, separated from the apices of the upper branches which they nearly meet, by rounded excisions; fourth branches, practically square, are seen from beneath in the centre of the widely excised ninth ventral segment.

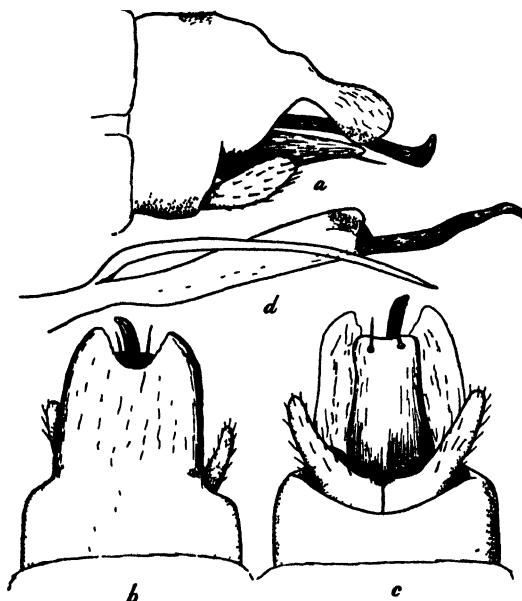
Length of the anterior wing, ♂, 1.5 mm.

MEXICO: Guerrero, Cocula, 27.ii.1935 (*A. Dampf*).

Type ♂ in the collection of the British Museum; paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, of Hamburg, from the same or neighbouring localities.

Guerrotrichia camera sp. n. Fig. 28.

Genitalia, ♂. Ninth dorsal segment produced into a large plate with a large, rounded excision at its centre, a patch of short bristles towards the basal margin; from the side,



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FIG. 28, a-d.—*Guerrotrichia camera* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d. penis.

the apex of the plate is clavate; penis with a pair of large, asymmetric black hooks arising from a membranous sleeve, the one produced considerably beyond the other, each considerably bent to one side; a slender external tube arises from about the centre; lower penis-cover large, apex truncate with a pair of stout bristles just before the apical margin; inferior appendages from beneath, rather slender, widely divergent, each with a black process, possibly a branch, on the upper margin towards the base.

Length of anterior wing, ♂, 1.5 mm.

MEXICO: Guerrero, Cocula, 27.ii.1935 (*A. Dampf*).

Type ♂ in the collection of the British Museum.

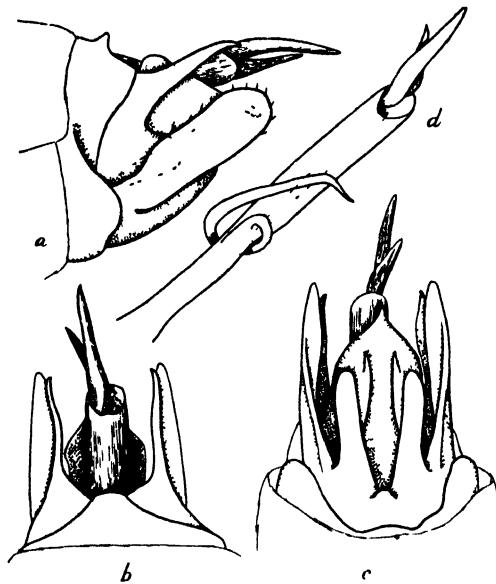
Lorotrichia gen. n.

Spurs, 0, 2, 3; ocelli present; the genus differs from *Exitrichia* in having no produced side-pieces to the ninth segment; from *Guerrotrichia* in having long, slender intermediate appendages and from *Dolotrichia* in the absence of a dorsal plate with the incurved hooks. Wings as in *Exitrichia* which the genus closely resembles.

Genotype, *Lorotrichia hiaspa* sp. n.

Lorotrichia hiaspa sp. n. Fig. 29.

Genitalia, ♂. Ninth segment produced at the centre of its dorsal margin; seen from the side, the produced centre is elevated in a triangular process; intermediate appendages long and slender, arising from broad bases; from the side, in a transparent preparation, it is



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FIG. 29, a-d.—*Lorotrichia hiaspa* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral, d, penis.

seen that the bases are produced into rather deep, rounded lobes; penis and sheaths projecting from a wide sleeve, the sheaths asymmetric, terminating in thick, black spurs; in a transparent preparation may be seen a small tube curling round the centre of the penis, projecting to one side; lower penis-cover wide, narrowing abruptly to a long finger-like, somewhat downturned apex; there is a pair of narrow, hooked processes situated towards the centre of its ventral surface, directed posteriorly; inferior appendages bifurcate, from above, long and narrow, about the same length as the superior appendages; from the side, wide with rounded apices; from beneath, the second branches arise side by side, rather long and stout and separated from each other at the base, by a small, triangular process; margin of the ninth ventral segment widely excised.

Length of anterior wing, ♂, 1.75 mm.

MEXICO : Chiapas, Dolores, 16.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum, paratypes ♂ in the British

Museum and the collection of Dr. G. Ulmer, from the same and neighbouring localities.

Mayatrichia gen. n.

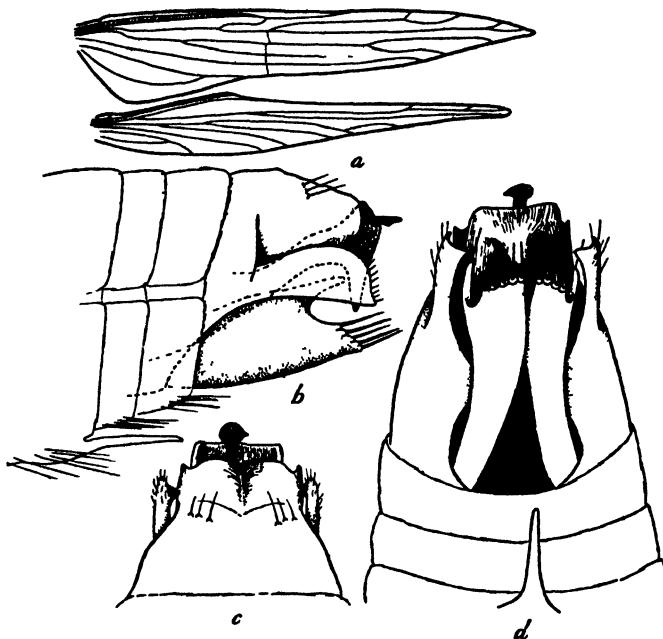
Spurs, 0, 2, 4; ocelli present; anterior wing broad, apex scarcely produced; posterior wing with the costal margin elevated towards the base, remainder of the wing produced but not particularly acute; neuration fairly complete; genitalia as given in the specific descriptions.

Genotype, *Mayatrichia ayama* sp. n.

The examples of the genus at present available are all incomplete.

Mayatrichia ayama sp. n. Fig. 30.

Genitalia, ♂. Margin of the ninth dorsal segment produced into two rounded lobes with an excision between and small triangular projections at the lateral angles; there is a



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FIG. 30, a-d.—*Mayatrichia ayama* sp. n. ♂; a. wings, b. genitalia, lateral, c. dorsal, d. ventral.

strong ridge before the apex, conforming with the outline of the apical margin and on the basal side of this ridge are two groups of stout bristles, three to each, arranged in line and set towards the side of the segment; the penis is long and slender, without, apparently, an external tube curled round the centre; apex rather clavate with a pointed "beak"; lower penis-cover trough-shaped; from above and beneath, apical margin truncate; from the side, there is a long, triangular, downwardly directed extension with an acute apex; side-pieces of the ninth segment from beneath, slender, with concave apical margins; from the side, broad towards the apex, with a very convex upper and straight lower margin, apex somewhat acute, upper margin, towards the apex, set with stout bristles; inferior appendages from beneath, long, separated at their bases but approximating and touching

towards the apices where they are slightly separated; each apical margin truncate, set with four or five strong bristles or spines and with the outer apical angle produced in a slender finger separated from the rest of the appendage by a rounded excision; a long pointed process to the sixth ventral segment.

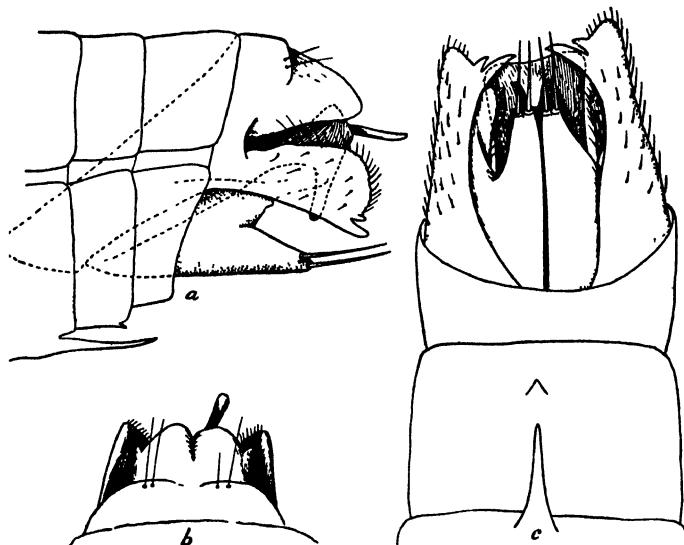
Length of the anterior wing, ♂, 1.75 mm.

MEXICO: Guerrero, Cocula, 27.ii.1935 (A. Dampf).

Type ♂ in the collection of the British Museum; paratypes in the British Museum and the collection of Dr. G. Ulmer, all from the same or other localities in the neighbourhood.

Mayatrichia rualda sp. n. Fig. 31.

Genitalia, ♂. Ninth dorsal segment produced into a large dorsal plate, apical margin from above, forming two rounded lobes with an excision between; midway across the segment is a ridge, also in the form of two rounded lobes separated by an excision; this



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FIG. 31, a-c.—*Mayatrichia rualda* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral.

ridge forms the base of the dorsal plate which, from above, carries a pointed process on each lateral margin; penis long and slender, without spines or spurs; lower penis-cover from beneath, broad, apical margin truncate or perhaps very slightly concave; from the side, the apex is strongly produced into a large, downwardly directed process having the appearance of a slipper with the toes directed downwards; side-pieces (?) of the ninth segment from beneath, broad at the base, inner margins concave, outer straight, apical margins truncate, each with a small pointed process towards the centro and a long, pointed inner apical angle, both directed inwardly; from the side, upper margin fringed and rounded, particularly towards the apex, of which the lower apical angle is produced into a pair of small processes, the lower the longer; inferior appendages from beneath, large, approximating and nearly touching towards their apices which are slightly separated; the apical margin is bifurcate to leave a large outer and an inner process with a narrow, truncate apex bearing a pair of very stout bristles or spines; from the side, the outer fork can only be seen in a balsam preparation and appears as a slender finger in front of the inner.

A long, slender process to the sixth ventral segment and a very short, triangular one to the seventh.

Length of the anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Barranca Honda, 24.ii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum; paratypes ♂ in the British Museum and the collection of Dr. G. Ulmer, from the same or neighbouring localities.

Polytrichia Sibley.

Polytrichia Sibley, 1926, *Bull. Lloyd Libr.*, 27 (Ent. 5) Trichoptera : 102.

Ochrotrichia Mosely, 1934, *Trans. R. ent. Soc. Lond.*, 82 : 162-163, fig. 56, syn. nov.

The genotype *P. confusa* is a north American insect. It is interesting to find that the genus is well represented in central America.

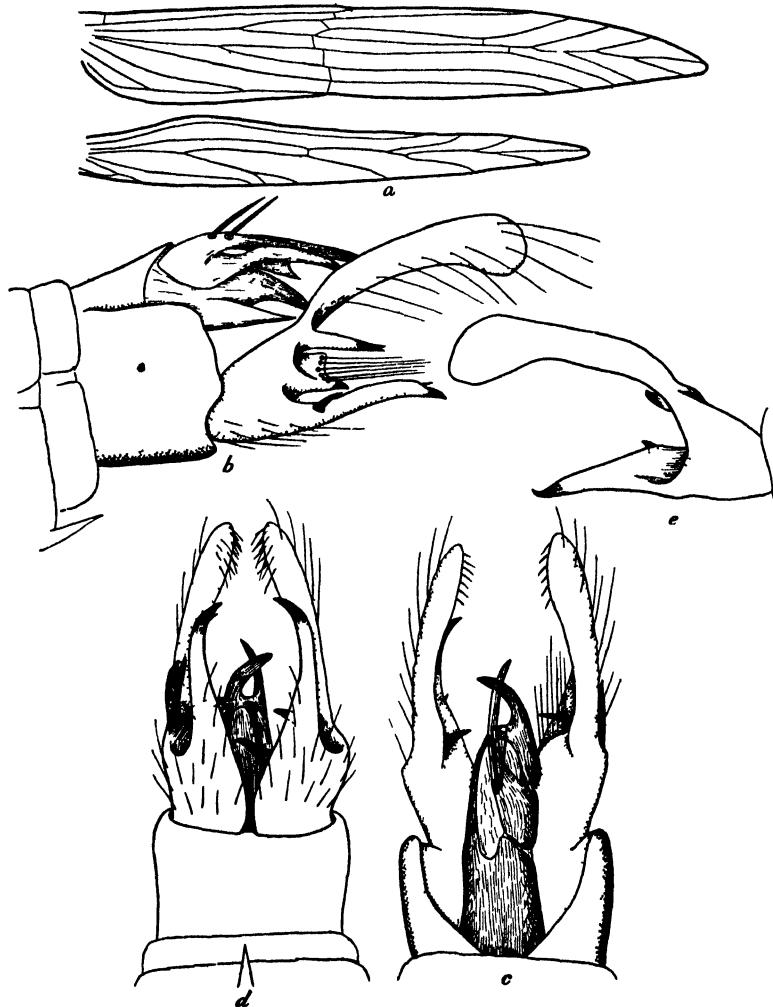


FIG. 32, a-e.—*Polytrichia arranca* sp. n. ♂; a. wings, b. genitalia, lateral, c. dorsal, d. ventral, e. the left inferior appendage, lateral.

The Jamaican species *Ochrotrichia insularis* must be transferred to this genus.

Polytrichia arranca sp. n. Fig. 32.

Genitalia, ♂. Ninth dorsal segment widely excised back to the apical margin of the eighth; in the excision is a complicated, asymmetrically branched upper penis-cover (?), with two long, peg-like, black spines situated about midway on one of its branches; the left branch is apparently articulated to the penis-cover at its base; beneath the cover but not visible from above, is a long, semi-transparent plate, broad at its base, as seen from the side, with the upper margin slanting downward to an acute apex which, from beneath is spatulate; penis apparently a long, slender tube entirely withdrawn in the example figured; inferior appendages asymmetrically branched; the left appendage more complicated than the right; there is a long upper branch to each, dilated at its apex, arising from a much forked basal portion as seen from the side; in the left branch, seen from the side, there arises in the basal portion, between two large and distinct forks, a rather broad process fringed with long hairs; this process is entirely wanting in the right branch; the lower fork of each bears a strong, black spine towards its base, directed posteriorly; from beneath, the lowest forks are seen to be long and caliper-shaped but rather shorter than the main branches and with acute apices; a short, pointed process to the seventh ventral segment.

Length of the anterior wing, ♂, 3 mm.

MEXICO : Chiapas, Barranca Honda, 24.ii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum.

Polytrichia aldama sp. n. Fig. 33.

Genitalia, ♂. Ninth dorsal segment widely excised half-way towards the apical margin of the eighth, the lower half from the side, large and quadrate; from beneath, produced at the centre of its apical margin; in the excision is an asymmetric penis-cover (?) forming two branches, the left branch (in the figure) with a bulge on its inner margin about midway, the branches curving towards each other; from the side, the apex of the right branch directed downward; penis very slender, reaching to the apex of its cover; inferior appendages very large and long; from the side, somewhat quadrate with the upper apical angle produced and rounded; they arise from slender stems; from above and beneath, outer angles produced and rounded with right-angled excisions along the inner margins towards the apices; inner apical margins set with strong teeth, longer along the basal margins of the excisions; a ventral process to the seventh ventral segment.

Length of the anterior wing, ♂, 2 mm.

MEXICO : Chiapas, Esmeralda, 19.xi.1930 (A. Dampf).

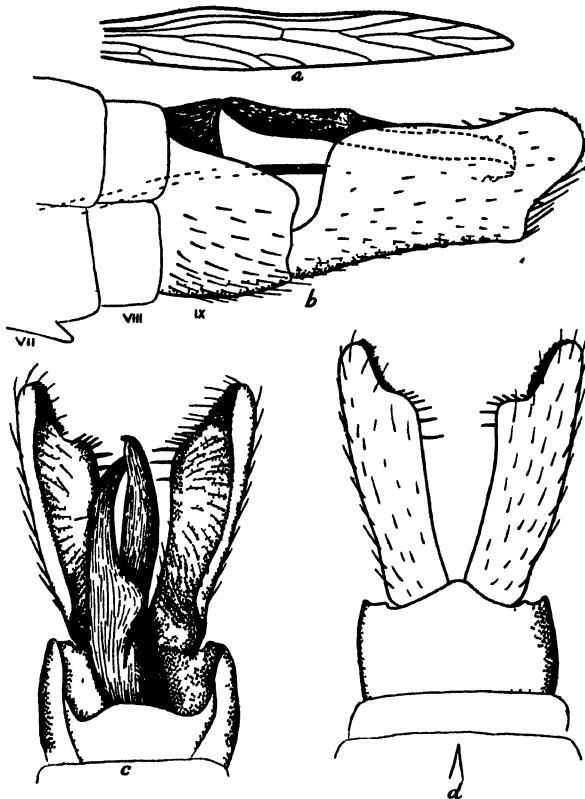
Type ♂ in the collection of the British Museum. Paratypes in the British Museum and the collection of Dr. G. Ulmer, from the same and neighbouring localities.

Polytrichia tenanga sp. n. Fig. 34.

Antennae about twenty-six-segmented.

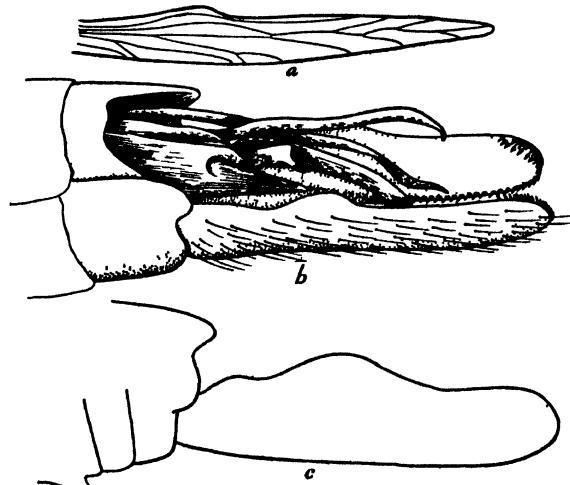
Genitalia, ♂. Apical margin of the ninth dorsal segment widely excised, the excision quadrate; in the excision may be seen a complicated series of asymmetric, twisted spines, possibly forming upper and lower penis-covers; the penis itself is a narrow tube with perhaps a small, sagittate apex; inferior appendages very long and narrow, much longer than in *aldama*; seen from the side, they have sinuous upper and straight lower margins; the lower margins are lined with evenly-spaced black teeth so that they resemble the jaws of an alligator; a short ventral process.

Length of the anterior wing, ♂, 2 mm.



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FIG. 33, *a-d.*—*Polytrichia aldama* sp. n. ♂; *a.* posterior wing, *b.* genitalia, lateral, *c.* dorsal, *d.* ventral.



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FIG. 34, *a-c.*—*Polytrichia tenanga* sp. n. ♂; *a.* posterior wing, *b.* genitalia, obliquely dorsal, *c.* inferior appendage, etc., lateral.

MEXICO: Chiapas, Saltenango de la Paz, 15.iii.1931 (A. Dampf).

Type and paratypes ♂ and ♀ from the same and neighbouring localities in the collection of the British Museum. Paratypes also in the collection of Dr. G. Ulmer.

Zumatrichia gen. n.

Spurs, 1, 3, 4. Antenna with about 20 segments, basal segment very large, with a large, round lobe arising from its lower surface; ocelli present but apparently only two in number; maxillary palpi: first and second segments short, third rather longer than the fourth and shorter than the fifth which is the longest; neuration of the wings as figured.

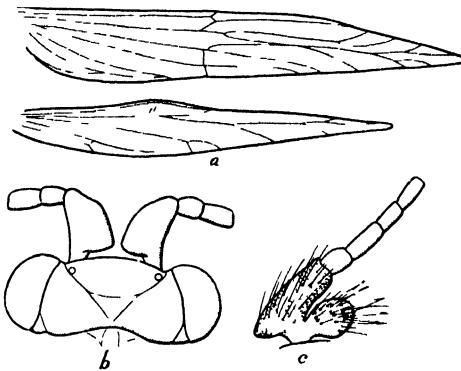
The head, in both the species of the genus here described, is unusually formed, with a curious structure at the base of each antenna, possibly a scent-organ. It seems clear that there are only two ocelli, a unique condition as far as is at present known, in the Trichoptera.

Genotype, *Zumatrichia filosa* sp. n.

Zumatrichia filosa sp. n. Figs. 35 and 36.

The general characters are given in the generic description.

Genitalia, ♂. From above, the ninth segment is very long, with a rounded, excised apical margin, apical angles produced into short processes; there is a membranous dorsal



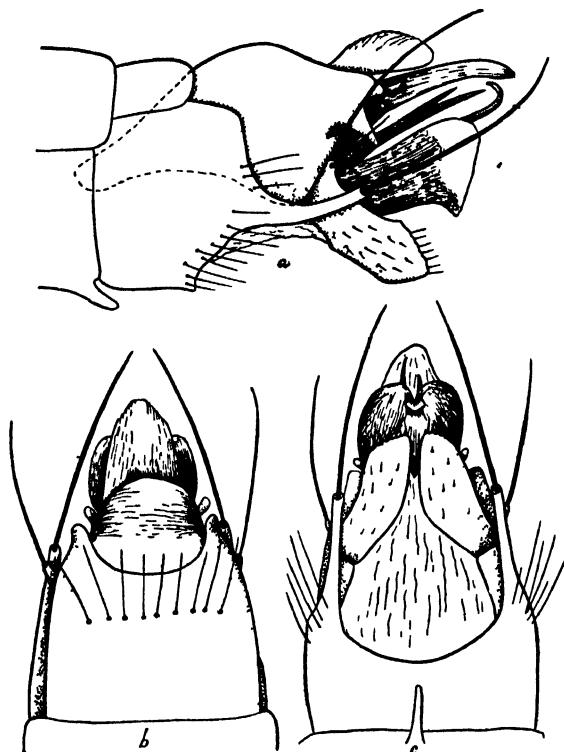
35

FIG. 35, a-c.—*Zumatrichia filosa* sp. n. ♂; a. wings, b. head, dorsal, c. basal segments of the antenna.

plate, rather inflated from the side; from the side, the apex of the ninth segment is trifurcate, the middle fork rather long, acutely triangular and directed downward; the upper, blunter and directed distally, the lowest is merely a finger-like base from which arises a very long, stout, black bristle; beyond the ninth segment is an upper penis-cover: from above, long and broad with a sub-acute apex; hidden beneath this is a series of three or four strongly chitinised, long, asymmetric spines, of which the apex of the outer is curved upwards; lower penis-cover from beneath, appears as a pair of rounded lobes, side-by-side, with the inner apical margins curving downward and joining each other to make a broad hook, acute from the side; from this aspect, the lower penis-cover is deep, with the upper margin very convex; from the side, the margin of the eighth sternite is produced at its centre in a long finger, curving slightly upward, from the truncate apex of which arises a still longer curved, black spine; inferior appendages from beneath, broad, inner margins close together, apices obliquely truncate and fringed with strong hairs; from the side, there

is a strong, triangular projection of the upper margin towards the base; eighth sternite with the apical margin widely excised; a process to the seventh sternite.

Length of the anterior wing, ♂, 3 mm.



36

FIG. 36, a-c.—*Zumatrixchia filosa* sp. n. ♂; a. genitalia, lateral, b. dorsal, c. ventral.

MEXICO: Chiapas, Saltenango de la Paz, 15.iii.1931; Santa Ana, 25.ii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum. Other paratypes from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.

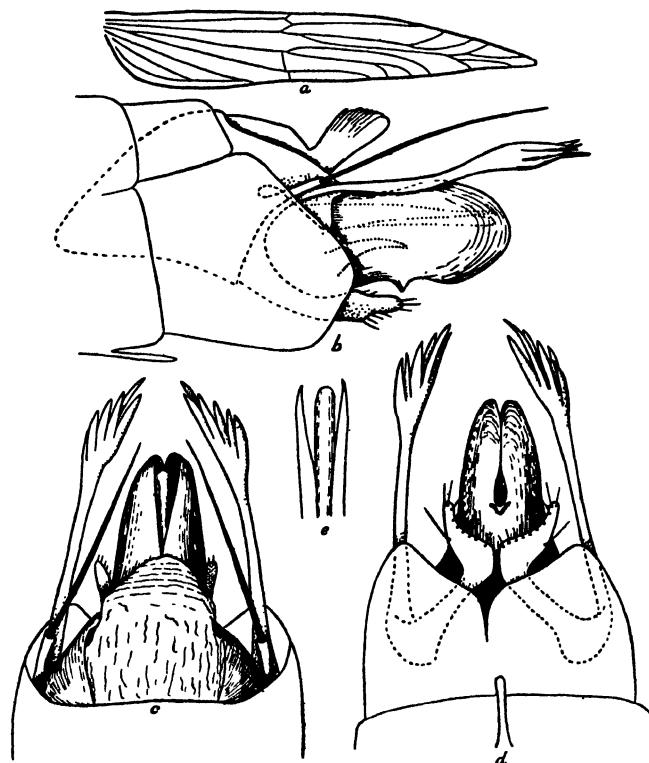
This species is characterised by the two pairs of black, spine-like bristles which almost amount to processes. They are, however, easily broken off and a careful examination should be made for their bases.

Zumatrixchia galtena sp. n. Fig. 37.

Genitalia, ♂. There is a membranous dorsal plate, triangular from above, directed slightly upward from the side; it arises from the widely excised margin of the eighth dorsal segment; on each side of the excision is a small finger-like process armed with a long, black bristle; beneath each of these small processes is another longer and stouter process with the apex dilated in a broad, pectinate structure, carrying five or six long teeth; upper penis-cover large, with a dorsal excision down to its base; the penis appears to be rod-like with a slightly longer sheath on each side; below it, seen from the side in a balsam preparation, is a pair of stout, curved hooks; inferior appendages small; they arise from long

slender stems, concealed within the eighth segment which is very widely excised; they broaden as they emerge beyond the margin of the excision and then diverge, the apices produced in rather slender and fringed processes; a slender process to the seventh ventral segment.

Length of the anterior wing, ♂, 2.75 mm.



37

FIG. 37, a-e.—*Zumatrichia gallena* sp. n. ♂; a. anterior wing, b. genitalia, lateral, c. dorsal, d. ventral, e. apex of penis and sheaths.

MEXICO : Chiapas, Saltenango de la Paz, 15.iii.1931 (A. Dampf).

Type ♂ in the collection of the British Museum. Paratypes ♂ and ♀, from the same and neighbouring localities, in the British Museum and the collection of Dr. G. Ulmer.

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INSECT TERATOLOGY. REDUPLICATION OF LEGS IN COLEOPTERA,
DIPTERA, AND HYMENOPTERA

By E. A. COCKAYNE, D.M., F.R.C.P.

WITH PLATES 1 TO 6.

[Read 5th May, 1937.]

DURING the last twelve years with the aid of gifts and loans from a few sympathetic entomologists I have made drawings and descriptions of twelve examples of reduplication of legs in Coleoptera, one in a Dipteron, and one in a Hymenopteron. Monstrosities of this kind taken under natural conditions are interesting and, even if they show nothing very new, it seems advisable to publish descriptions with plates illustrating the nature of the abnormality in each case. Many published descriptions of insects with extra legs are very brief, and the figures, when a figure is given, are often small and too lacking in detail to be of much value. In order to try to avoid this defect I have drawn the affected leg only and have omitted minute details of structure, which might have obscured more essential points.

I have adopted the same classification as in my previous paper on extra wings in Lepidoptera. In this series there are no examples of simple duality, which would have fallen into Group I. Two specimens fall into Group II, being examples of the repetition of a leg or part of a leg, which in structure belongs to the opposite side of the body to the original leg or part of a leg. They resemble the mutant "Crippled" of *Drosophila melanogaster* described by Taku Komai. This mutant has the whole or part of a meso- or metathoracic leg doubled, the one part having the normal position and direction and the other being its mirror image. The two examples which fall into this group are the *Galerucella tenella* and the *Laccobius ytenensis*. In the *Galerucella* the trochanter of the left mesothoracic leg appears to be a fused double one, the femur bifurcates and each part gives origin to a tibia and tarsus. The bifurcated parts of the femur and the tibiae and tarsi are mirror images of one another with the dorsal surfaces apposed. It is possible that the original femur is suppressed and these are the two extra ones. The *Laccobius* has the third tarsal segment of the right metathoracic leg much thickened, and from it arise two terminal parts, each of two segments, which are mirror images of one another.

Of the remaining specimens eleven, including the Dipteron and the Hymenopteron, follow Bateson's Law and fall into Group III, though there is some doubt about the *Calosoma* and the *Carabus nitens*.

It is well known that the great majority of cases of reduplication of appendages, with the possible exception of antennae, can be shown to follow Bateson's Law, and the more complete the reduplication the easier it is to show this. Bateson himself thought that reduplication of wings in Lepidoptera was an exception to his law, but in my paper published in 1927 I proved that this is not so, and Henke and Preiss in 1930 confirmed it. As a rule only the more incomplete and imperfect examples in all Orders appear to be exceptions, and this makes one very loath to say that a reduplicated appendage does

not conform with the arrangement described by Bateson. He showed that when reduplication takes place there is an original appendage and two extra ones, the first, that nearer to the original appendage, being its mirror image, and the second, that farther away, being a mirror image of the first. Thus, if the original appendage is a right one, the first extra appendage is structurally like a left one and the second extra appendage is like a right one. Partial fusion of all three or of the two extra ones is, however, common, and suppression of parts of the original or of the extra appendages often occurs, or there may be a combination of fusion and suppression of parts, and it is this fusion or suppression that makes some examples of reduplication appear to be exceptions to Bateson's Law and makes it impossible to prove that others are in conformity with it.

It is believed that injury is the usual cause of reduplication and that the growing extremity of an embryonic appendage may be so damaged as to leave a major part, which produces the original appendage, and a minor part, which produces the two extra appendages in the imago. If the injury divides the growing point vertically, *i.e.* at right angles to the horizontal plane of the insect, the original and the extra parts will lie side by side with their dorsal surfaces uppermost, horizontal reduplication. The extra appendages, however, may be anterior to the original, subdivision A, or posterior to it, subdivision B. On the other hand, if the growing point is divided horizontally, *i.e.* parallel to the horizontal plane of the insect, the reduplication will take place either upwards or downwards, vertical reduplication, and the extra appendages will lie above, subdivision C, or below the original one, subdivision D, so that one will have its dorsal and the other its ventral surface directed upwards. In Coleoptera horizontal reduplication is much commoner than vertical, and in the present series there are seven examples of the former, but only two of the latter. Both the Dipteron and the Hymenopteron show horizontal reduplication.

The following is the list of species, the leg or part of the leg affected being mentioned in each case.

GROUP III A.

Agonum sexpunctatum L. (the whole of the right prothoracic leg).

Cratichneumon annulator F. (the whole of the left mesothoracic leg, with suppression of the left metathoracic leg).

Musca domestica L. (the whole of the left metathoracic leg).

Prionus coriarius L. (the femur of the right metathoracic leg).

GROUP III B.

Ceraglossus valdiviae Hope var. *inexpectatus* Kr.-Koschl. (the femur of the left prothoracic leg).

Lucanus cervus L. (the whole of the left mesothoracic leg).

Necrodes oculans Vig. (the femur of the left mesothoracic leg).

Carabus nitens L. (the femur of the right metathoracic leg).

Calosoma auropunctatum Payk. (the tibia of the right metathoracic leg).

GROUP III D.

Ceraglossus chilensis Eschsch. var. *gloriosus* Gerst. ab. *hipocrita* Kr.-Koschl. (the femur of the left mesothoracic leg).

Carabus italicus Dej. (the femur of the left mesothoracic leg).

The Hymenopteron, *Cratichneumon annulator*, is interesting, because the huge triple coxa has caused complete suppression of the metathoracic leg of the

same side, though the mesothoracic leg, which is reduplicated, is an excellent and unusually perfect example of Bateson's Law. Reduplication of any appendage is uncommon in Hymenoptera, which in the early stages are well protected from injury. In Diptera reduplication of the appendages is also rare, apart from the two mutations of *Drosophila*, in which the condition is inherited. The appendages are internal in the larval and pupal stages, and are therefore unlikely to be damaged. Several examples are recorded by Morgan, Bridges, and Sturtevant in their paper on the genetics of *Drosophila*. They give a figure (34b and b') of one with the two prothoracic legs fused together up to the tarsi, which are separate. It is, however, possible that this is really an example of reduplication of one prothoracic leg with suppression of the other, and, if so, it resembles in some respects the *Cratichneumon* described in this paper. They also give figures of a *Drosophila* with reduplication of the left metathoracic leg, in which the two femora, tibiae and tarsi are mirror images of one another, of one with the left wing reduplicated in conformity with Bateson's Law, the two extra wings in secondary symmetry being incompletely developed, and of another with a double balancer (38c), the anterior one intermediate in structure between a wing and a balancer.

There is one specimen which I am unable to assign to any of the three groups. It is a *Philonthus fimetarius*. The left prothoracic leg has a femur with the distal end greatly thickened, and a normal tibia, with a tarsus of five segments, arises from the usual site, but a second tibia, with a tarsus of five segments, springs from the anterior aspect of the femur about two-thirds of the way along the shaft, and that part of the shaft, from which it springs, is not modified in any way so as to resemble the point of origin of a normal tibia. This extra tibia is slender proximally, but distally it is wider than the normal one. There is, however, nothing in its structure to suggest that it is a fused double tibia, nor does it arise from a point where one would expect a fused double tibia following Bateson's Law to arise. On the other hand, it is not a mirror image of the other tibia, nor can it be an example of simple duplicity, for only a part of the leg is double. I have seen no example of reduplication resembling it and am unable to offer an explanation of it.

Galerucella tenella L. (Phytophaga). Redbourn, Herts, 26.v.1928
(C. T. Gimingham).

Looking at the ventral surface of the beetle the origin of the legs is normal except that that of the left metathoracic leg is very slightly displaced outwards. The coxa of this leg appears to be quite normal, but the trochanter is partially divided by a longitudinal groove and the part anterior to the groove is divided by two transverse grooves. It may therefore be a fused double trochanter. The femur of this abnormal metathoracic leg bifurcates near the middle, and one half points directly upwards and the other downwards. The latter is shorter and less perfectly formed and gives origin to a very dark coloured tibia, much shorter and rather narrower than a normal one and curved. From its distal end arises a tarsus with only one segment, which is much smaller than a normal proximal segment. The other part of the femur gives origin to a tibia and a tarsus, both of which are well developed, the tarsus having the usual five segments, the distal one terminating in two claws.

The distal ends of the bifurcated femur and the two tibiae are mirror images of one another, but I can see no trace of a third femur. There is nothing to support the view that the bifurcated femur with its two tibiae and tarsi

represents two extra legs and that the original leg is completely suppressed, or that one of the extremities of the bifurcated femur is the original leg and that the other is a fused double leg. If neither alternative is true the leg does not conform with Bateson's Law. On the other hand, the leg is so normal at its point of origin that it is difficult to believe that the beetle is a double monster, as no doubt Cappe de Baillon would classify it. The figure shows the left metathoracic leg from behind looking at the anal end of the beetle (pl. 3, fig. 3).

Laccobius ytenensis Sharp (HYDROPHILIDAE) (teste H. Donisthorpe).
New Forest, 15.viii.1928.

The right metathoracic leg is partially reduplicated. The third tarsal segment is much thickened and gives origin to two terminal portions, each consisting of two segments, the posterior one being shorter and thicker than the anterior one. Both appear to end in a single claw, but the claws of a normal tarsus lie so close together that it is possible that there are in reality two. There is no clear evidence that either of these terminal portions is formed by the fusion of double segments, so that is uncertain whether the specimen agrees with Bateson's Law or not (pl. 2, fig. 3).

Agonum sexpunctatus L. (Adephaga, CARABIDAE). Wassow, Stettin, 1890.

The right prothoracic leg is reduplicated. There is a very large coxa divided into two main parts by a ridge, and from the posterior and slightly smaller part a femur with tibia and tarsus arises, while from the anterior part two additional femora, each with a tibia and tarsus, arise. The coxa is triple, as is clearly shown by the fact that there are three conical elevations on it in place of the usual single one. The two posterior cones bear the normal relation to the two posterior femora, their long axes being at right angles to the ventral surfaces of the femora, but the anterior cone bears an abnormal relation to its femur, its long axis being at right angles to the anterior surface of the femur. The femur arising from the posterior part of the coxa is the original femur, the other two being the extra femora. The original femur is only slightly smaller than the femur of the opposite side, and the femur itself and its tibia and tarsus are almost perfectly formed. The two extra femora are smaller and both are a little malformed. The tibia arising from the middle femur is narrow and somewhat twisted, but the arrangement of its spines shows that it is a mirror image of the original tibia, and structurally like a left tibia. The tarsus belonging to it is nearly perfect. This is the first extra leg. The anterior leg has a tibia, structurally a right leg like the original one, and, as the spines on its tibia show, this leg is a mirror image of the middle one, and is the second extra leg. The reduplication is unusually complete and the specimen is a very perfect example of Bateson's Law. The other legs of the beetle are normal. In the drawing the ventral aspect of the legs is shown. The hollow at the distal end of each tibia is left unshaded to make the other details of structure clearer (pl. 3, fig. 1. $\times 24$ approximately). The second drawing shows the coxa seen from the inner side (pl. 3, fig. 2).

Cratichneumon annulator F. (Hymenopt. ICHNEUMONIDAE). Female. Powerscourt deer park, Co. Wicklow, 28.vii.1926 (J. N. Halbert).

I am indebted to Mr. A. W. Stelfox for the loan of this insect which is now in the National Museum of Ireland.

At first sight there appears to be a fusion of the left meso- and metathoracic legs with partial reduplication of the mesothoracic shown by the presence of two tarsi fused at the base. I think, however, that this is not the true explanation. I believe that there has been an injury which caused reduplication of the mesothoracic leg and that the metathoracic leg is entirely suppressed either as a result of the same injury or owing to the pressure of the enormously enlarged coxa of the reduplicated leg. If so the whole of the left mesothoracic leg is triple, the coxae, trochanters, femora and tibiae being fused together, the one tarsus being separate and the other two partially fused. The leg takes origin from the normal site of origin of a mesothoracic leg and the femur has no white dorsal patch like a metathoracic femur, so that I think it is the metathoracic leg that is suppressed. The coxa is divided into two main parts by a groove, the postero-internal part representing the original coxa and the antero-external part, which is divided by a less distinct groove, representing the two extra coxae. The trochanter and femur show a similar arrangement less clearly. The tibia is undoubtedly a triple one. There are six large spines instead of the usual two. In the drawing, where it is foreshortened, the posterior part is the original tibia and gives rise to a single tarsus and the spines in relation to this tarsus are partly hidden, the distal part of one lying behind this tarsus and the proximal part of the other behind the middle tarsus. The two spines in relation to the middle tarsus are hidden behind it, but the two in relation to the anterior tarsus are plainly visible. To show the arrangement better I have drawn the distal end of the tibia showing its inner aspect, leaving out the tarsi, and have shown all six spines, though actually the one drawn in dotted lines is not visible, being hidden by the anterior tarsus. The first or proximal segments of the extra tarsi are fused for the greater part of their length, but a groove shows the division. The last four segments of each are free and almost perfect, though reduced in size. Though the structure of the three tarsi does not show very clearly that the two extra ones are mirror images of one another and that the middle one is a mirror image of the original tarsus, there can be no doubt that this is the actual arrangement. The whole leg is therefore in conformity with Bateson's Law (pl. 1. figs. 1 and 2).

Musca domestica L. Female. (Dipt. MUSCIDAE.)

The specimen kindly given to me by Mr. O. J. Janson has a reduplication of the left metathoracic leg. The left coxa is very slender at its point of origin and then becomes very wide. The slender part is twisted and ridged and the wider part has an irregular surface. Posteriorly it is paler and smoother with a somewhat rounded end, from the upper surface of which arises a large seta, directed backward. Several small setae also arise from this part and point in the same direction. This portion is, I think, part of a femur. From the external aspect of the coxa arises a very broad deep femur rather shorter than that of the opposite leg and bifurcated at its distal end. From each of its bifid extremities springs a tarsus and tibia, both shorter than those of the opposite leg. That on the outer side is paler. As the drawing shows, the inner tibia with its tarsus is in structure like a right leg and the outer one like a left leg, the two being mirror images of one another. The outer tarsus is paler than the inner one, but both have five segments, the terminal segment of each ending in two claws and a pulvilli.

I think the specimen is in agreement with Bateson's Law. The coxa is a fused triple one completely twisted round, and the original femur is almost

completely suppressed. What appears to be the rounded end of the coxa is really a part of the original femur and the large seta is the ventral seta of the femur. The side of the double extra femur shown in the drawing is the second extra femur, like a left one in structure, the outer tibia and tarsus are also the second extra ones, while the inner and invisible side of the big femur is the first extra femur with its tibia and tarsus. The first extra femur, tibia and tarsus are mirror images of the original leg, only represented by a small part of the femur, and the second extra leg is a mirror image of the first (pl. 2, figs. 1 and 2).

Prionus coriarius L. (Longicornia, PRIONIDAE).

The right metathoracic leg shows partial reduplication. The femur is much thickened in all diameters; the tibia is slightly thickened at its proximal end and rapidly increases in width, bifurcating near its distal extremity. The posterior or internal part after bifurcation has the usual two spines of a single tibia, and the tarsus arising from it is normally developed, but the anterior or external part has two much shorter spines, the anterior of which is bifid and has a tarsus with unusually widened segments arising from it. The third segment, or what appears to be the third segment, has two lateral expansions like those of a normal tarsus, but there is also a central portion formed of two other lateral expansions fused together. On either side of this central portion arises another segment, the one lying to the inner side being very short, while that to the outer side is longer. If I am right in counting the segment with lateral expansions as the third, the inner segment is a complete fourth one with traces of a fifth and the outer one is a fourth one with a small aborted fifth one. The specimen is evidently in accord with Bateson's Law. The inner part of the bifurcated tibia represents the original tibia, and the outer part is really a fused double tibia representing two extra tibiae with two extra tarsi, fused or partially fused together, the inner a mirror image of the original tibia and tarsus and the outer one a mirror image of the inner one. The figure ($\times 8$) shows the limb from the ventral aspect (pl. 4, fig. 2) and the much enlarged figure of the distal end of the tarsus shows its double nature very clearly (pl. 5, fig. 1). The most interesting feature is that the fused double tibia is not as wide as the single original one. It has only two claws, though one would expect two lateral ones and two central ones or a fused double one in the centre.

Ceraglossus valdiviae Hope. var. *inexpectatus* Kr.-Koschl. (CARABIDAE.)
Cordillera Pelado, (Kraatz-Koschlau), 1890.

The left prothoracic leg is partially reduplicated. The femur bifurcates near the junction of the middle and distal thirds and proximal to the bifurcation a shallow groove indicates the division into two parts; the posterior of the two branches gives origin to a normal tibia with its tarsus; the anterior branch is shorter and narrower, and though a rudimentary socket is present there is no trace of a tibia. The structure of the limb is too imperfect to show whether it obeys Bateson's Law or not. It is, however, probable that the posterior branch is the original femur and the anterior branch is a fused double femur representing the two extra ones. The figure shows the ventral aspect of the leg (pl. 6, fig. 4. $\times 8$).

Lucanus cervus L. (Lamellicornia, LUCANIDAE). Male. Chichester, vii.1924
(Rev. C. E. Tottenham).

The left mesothoracic leg is triple, and at first sight appears to be an exception to Bateson's Law, but further examination shows that it conforms with it.

There is a very large coxa branching into two parts. From the anterior part springs a femur, directed upwards, with a small tibia and tarsus, the latter bent and having only three segments. The tibia is twisted, but its structure is that of a left tibia. This part of the coxa with its femur, tibia and tarsus must be regarded as the original leg. The posterior branch of the coxa becomes narrow and then widens again and from it arise two femora. The anterior of the pair is a right femur in structure and it gives origin to a small tibia and a tarsus, with only three segments, which is bent sharply backwards on itself in a ventral direction. The posterior femur, tibia and tarsus are well-formed and considerably larger than the others, though not as large as the corresponding parts of the right leg, and their structure is that of a left leg. The length of the right femur is 11 mm., of the left original femur 8 mm., of the first extra one 6.5 mm., and of the second extra one 9 mm.; the length of the right tibia is 12 mm., of the left original 4 mm., of the first extra tibia 5 mm., and of the second extra tibia 9 mm., and the length of the right tarsus is 11 mm., that of the second extra tarsus on the left is 8 mm. Thus there are two extra legs in secondary symmetry with one another, the anterior of the two being a mirror image of the original leg, and the posterior one being a mirror image of the anterior (pl. 1, fig. 3).

Necrodes oculans Vig. (SILPHIDAE) (teste K. G. Blair). Bedagei, Sumatra.
About 600 metres. 1889 (*I. Z. Kannegieter*).

The femur of the left mesothoracic leg is very broad at its proximal end and bifurcates at the junction of the proximal and middle thirds. The anterior or external part of the femur after its division is much the broader and longer and appears to be a continuation of the main femur, though it curves slightly inwards. It gives origin to a tibia and tarsus, both well formed. The posterior or internal part of the femur after its bifurcation is almost at right angles to the main femur and widens towards its distal end, which is notched. It has no tibia or tarsus arising from it. The abnormal femur and tibia are very slightly shorter than those of the opposite leg, but the tarsus is a good deal shorter, being about 4 mm. long instead of about 6 mm. The larger part of the bifurcated femur is probably the original femur and the smaller is a fused double femur. If so, the reduplication follows Bateson's Law. The figure (pl. 4, fig. 1) shows it from the ventral aspect and the tibia is foreshortened. (X 8.)

Carabus nitens L. (CARABIDAE) (teste K. G. Blair). Berlin.

The right metathoracic leg is partially reduplicated. The femur bifurcates near its distal end; the outer portion is longer than the inner and each has a well-formed socket for the articulation of a tibia. From the outer portion a normal tibia and tarsus arise, both very little smaller than those of the opposite side, while the femur appears to be of normal length. From the inner portion a very short and narrow tibia arises, and this terminates in a jagged edge which may be natural or it may have been broken. There is no sign that either branch

of the bifid femur or either of the two tibiae is a fused double one. If it is, the fusion must be very complete. It is possible that the reduplication conforms with Bateson's Law, but there is no proof that it does so (pl. 6, figs. 8 and 9. $\times 10$).

The figure is drawn with the ventral side uppermost and therefore shows the anterior aspect of the limb. Fig. 9 shows the distal end of the femur with the small and large tibiae arising from it.

Calosoma auropunctatum Payk. (CARABIDAE) (*teste* K. G. Blair).

The right metathoracic leg is partially reduplicated. The tibia bifurcates near its middle; the external part, probably the original tibia, has a normal tarsus, and the internal part has a tarsus with only one segment, which is both shorter and narrower than the proximal segment of the tarsus arising from the other part. The two parts are slightly rotated so that their ventral surfaces incline towards one another. It is probable that the part bearing the aborted tarsus is a fused double part representing the two extra terminal parts of the tibia, the side nearer to the original termination being a mirror image of it and the two fused parts being in secondary symmetry. Owing to the absence of additional spines on this part and the rudimentary character of the tarsus this cannot be proved, though it is probably in conformity with Bateson's Law. The figure shows the limb from the ventral aspect (pl. 6, fig. 1. $\times 8$), and therefore represents its posterior surface.

Ceraglossus chilensis Eschsch. var. *gloriosus* Gerst. ab. *hipocrita* Kr.-Koschl. (CARABIDAE). Cordillera, S. America (*Kraatz-Koschlau*), 1889.

The left mesothoracic leg is reduplicated. A single femur with a normal tibia and tarsus is directed forwards and a double femur is directed backwards at right angles to the single one. Both arise from a coxa and trochanter, which are presumably fused triple ones. The reduplication is very unusual, because the original femur and the first extra one have their ventral surfaces facing one another, or to be more exact their extero-ventral aspects are facing. Thus they are mirror images, but lie venter to venter instead of side to side, and the leg is an example of vertical instead of the usual horizontal reduplication. The first and second extra femora have their dorsal surfaces fused, and on each of the free ventral surfaces there is a socket for the insertion of a tibia, as is shown in the figure. They are mirror images of one another in secondary symmetry. The first extra femur bears a vestigial tibia in the form of a small chitinous spike, but there is no trace of a tibia arising from the second one. The extra limb is very little smaller than the normal one of the opposite side. The figure shows the original and extra femora from the dorsal aspect and therefore shows their posterior surfaces. The second spine of the tibia is hidden by the proximal segment of the tarsus. The ventral aspect of the fused double femur is also figured to show the socket for the insertion of the second extra tibia (pl. 6, figs. 2 and 3. $\times 8$).

Carabus italicus Dej. (CARABIDAE) (*teste* K. G. Blair). France, Dourbes, Basses Alpes.

The left mesothoracic leg is partially reduplicated. There is a single coxa and trochanter, from the anterior, really the upper, part of which arises a femur,

tibia, and tarsus, all of normal shape, though the inner spine of the tibia is much reduced in size. From the posterior, really the lower, surface a second femur arises, which is nearly as long as the other, but is ill-formed at its distal extremity and with no tibia arising from it. On examining the distal end of this femur it is seen that there are two tibial sockets, one facing that of the other femur and one facing in the opposite direction. From this it is clear that the femur without a tibia is a fused double femur, the dorsal surfaces of the two femora being fused together. The arrangement agrees with that expected by Bateson's Law, but is unusual because the reduplication is vertical and in the downward direction. The femur with a tibia and tarsus is the original femur, the other is the fused double one representing the two extra femora. The first extra femur has its ventral surface facing the ventral surface of the original femur of which it is the mirror image, and the second has its ventral surface facing in the opposite direction, and is therefore a mirror image of the first extra femur. The distal end of the fused double femur is bent over towards the original femur.

The figure (pl. 6, fig. 5. $\times 8$) shows the leg seen from the ventral aspect of the insect and represents what is really the anterior aspect of the original femur and of the fused double femur. The other figures (pl. 6, figs. 6 and 7. $\times 8$) represent the tibial sockets of the first and second extra femora respectively.

Philonthus fumetarius Grav. (STAPHYLINIDAE) (*teste* H. Donisthorpe).
(F. J. Coulson.)

The left prothoracic leg is partially reduplicated. The distal half of the femur is very greatly thickened and bears a tibia and a five-jointed tarsus arising from the usual situation, but from the anterior aspect of the ventral surface a second tibia with a tarsus of five segments arises springing from a point little more than two-thirds of the way along the shaft. The extra tibia is very slender proximally, but distally it becomes wider than the original tibia. The distinctive structure of the tibia in this species should make it easy to decide whether the extra tibia is a single or fused double one, but I have been unable to satisfy myself on this point. The spines of the extra tibia are all unusually long and pale, like the two long spines of a normal tibia, though their number seems to be correct. The spines of the original tibia, however, are all short and dark, though their number too is normal. The arrangement is most unusual, and I have seen no case of reduplication quite like it. It does not appear to conform with Bateson's Law (pl. 5, figs. 2 and 3. $\times 128$).

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EXPLANATION OF PLATES.

PLATE 1.

FIG. 1. *Cratichneumon annulator* F. Reduplication of left mesothoracic leg with suppression of left metathoracic leg.
 2. *Cratichneumon annulator* F. Inner aspect of distal end of triple tibia.
 3. *Lucanus cervus* L. Left mesothoracic leg, showing original leg L, first extra leg R', and second extra leg L'. (× 4.)

PLATE 2.

FIG. 1. *Musca domestica* L. Left metathoracic leg, original suppressed, first extra leg R', second extra leg L', and normal left leg L unshaded. (× 28 approx.)
 2. *Musca domestica* L. First extra tibia and tarsus R', second extra tibia and tarsus L'.
 3. *Laccobius ytenensis* Sharp. Tibia and tarsus of right metathoracic leg, ventral aspect. (× 57 approx.)

PLATE 3.

FIG. 1. *Agonum sexpunctatum* L. Right prothoracic leg, ventral aspect. (× 24 approx.)
 2. *Agonum sexpunctatum* L. Internal aspect of triple coxa with original coxa on left.
 3. *Galerucella tenella* L. Left metathoracic leg seen from behind. (× 52 approx.)

PLATE 4.

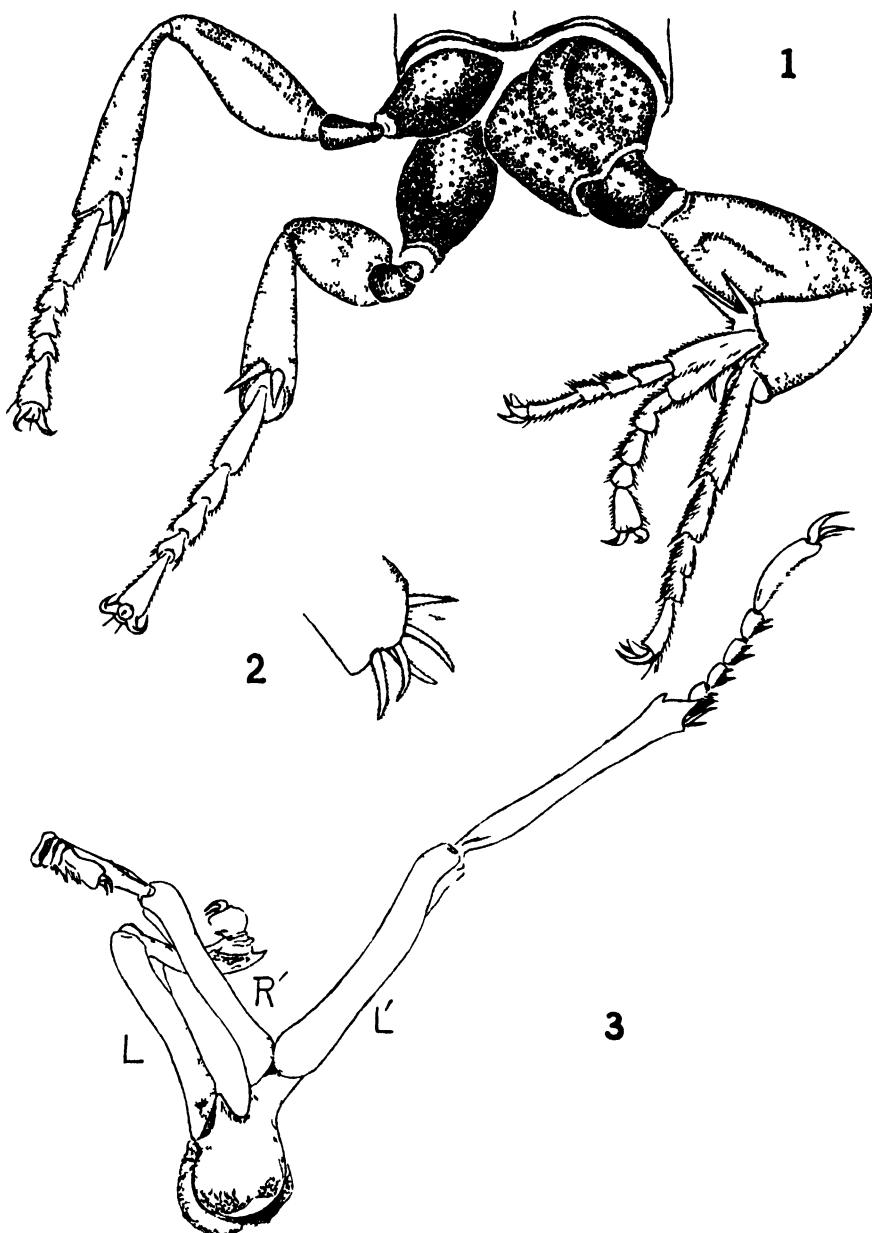
FIG. 1. *Necrodes oculans* Vig. Left mesothoracic leg, ventral aspect. (× 8.)
 2. *Prionus coriarius* L. Right metathoracic leg, ventral aspect. (× 8.)

PLATE 5.

FIG. 1. *Prionus coriarius* L. Distal end of fused double tarsus, ventral aspect. (× 40 approx.)
 2. *Philonthus fumetarius* Grav. Left prothoracic leg, dorsal aspect. (× 128 approx.)
 3. *Philonthus fumetarius* Grav. Left prothoracic leg, ventral aspect. (× 128 approx.)

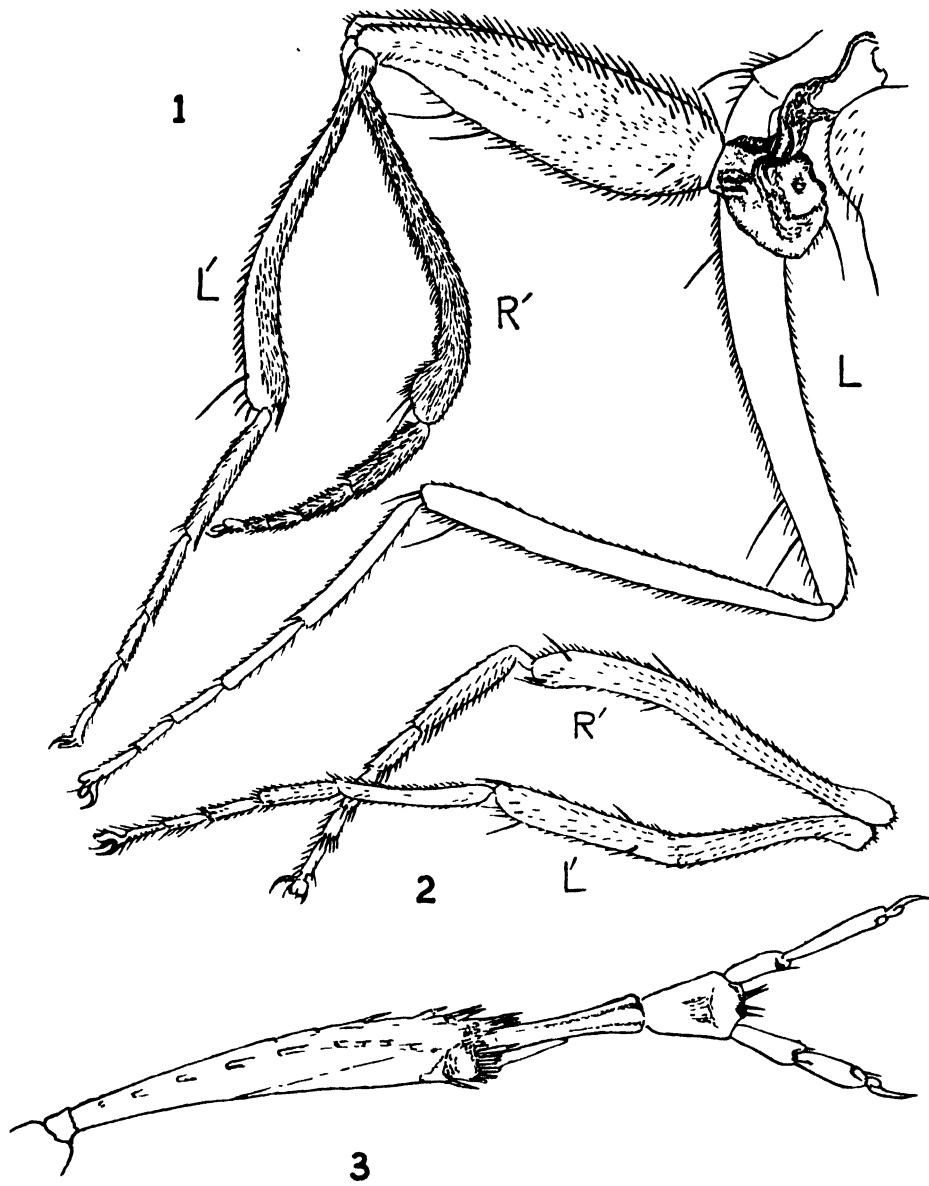
PLATE 6.

FIG. 1. *Calosoma auropunctatum* Payk. Right metathoracic leg, ventral aspect. (× 8.)
 2. *Ceraglossus chilensis* Eschsch. var. *gloriosus* Gerst. ab. *hypocrita* Kr.-Koschl. Left mesothoracic leg, posterior surface. (× 8.)
 3. *Ceraglossus chilensis* var. *gloriosus* ab. *hypocrita*. Ventral aspect of fused double femur showing socket for insertion of second extra tibia.
 4. *Ceraglossus valdiviae* Hope var. *inexpectatus* Kr.-Koschl. Left prothoracic leg, ventral aspect. (× 8.)
 5. *Carabus italicus* Dej. Left mesothoracic leg, anterior aspect. (× 8.)
 6. *Carabus italicus* Dej. Socket of first extra tibia.
 7. *Carabus italicus* Dej. Socket of second extra tibia.
 8. *Carabus nitens* L. Right metathoracic leg, anterior aspect. (× 10.)
 9. *Carabus nitens* L. Distal end of fused double femur showing bifid extremity with two tibiae arising from it.



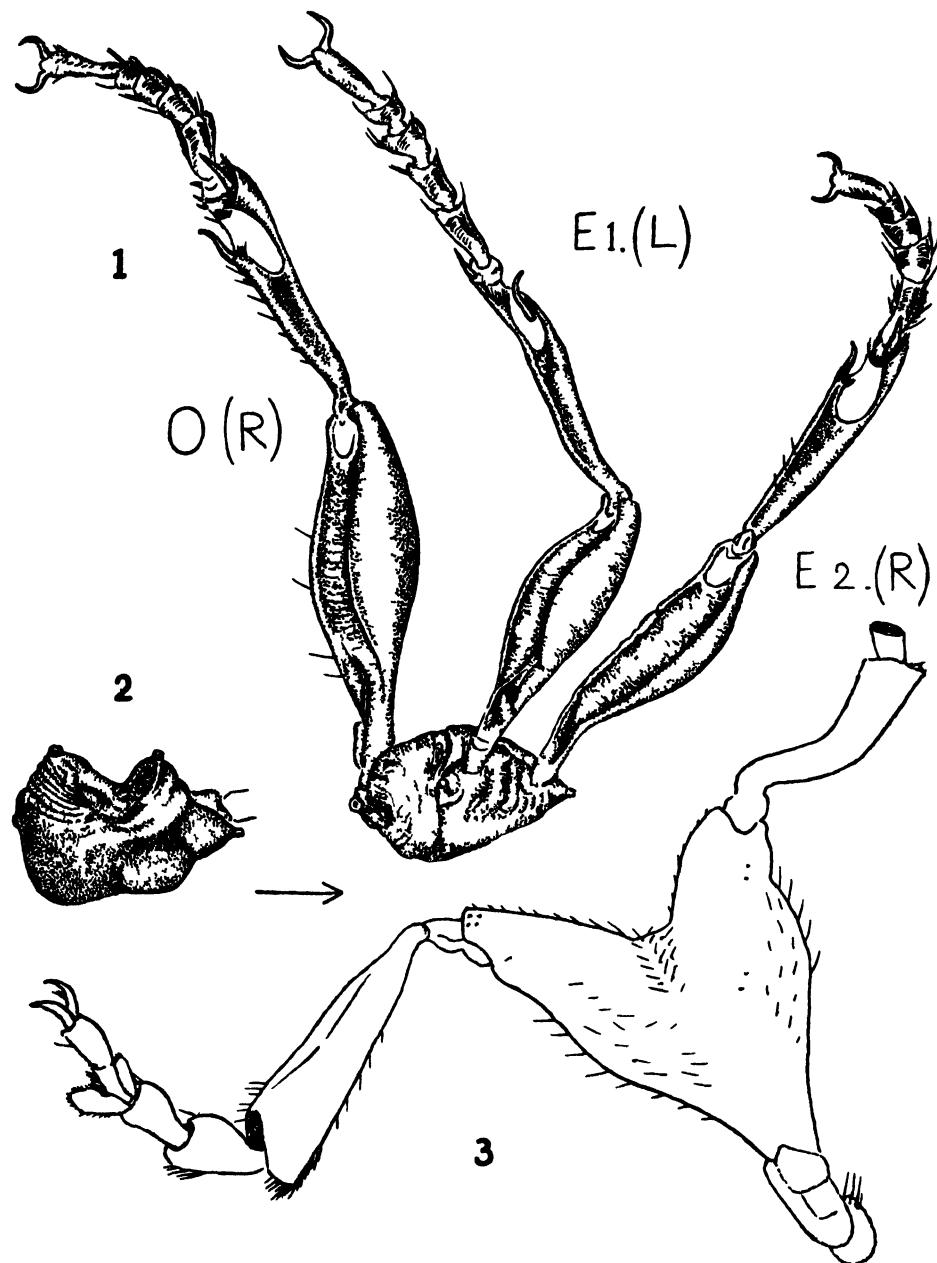
ENGRAVED BY STAR ILLUSTRATION LONDON

Reduplication of legs in insects.



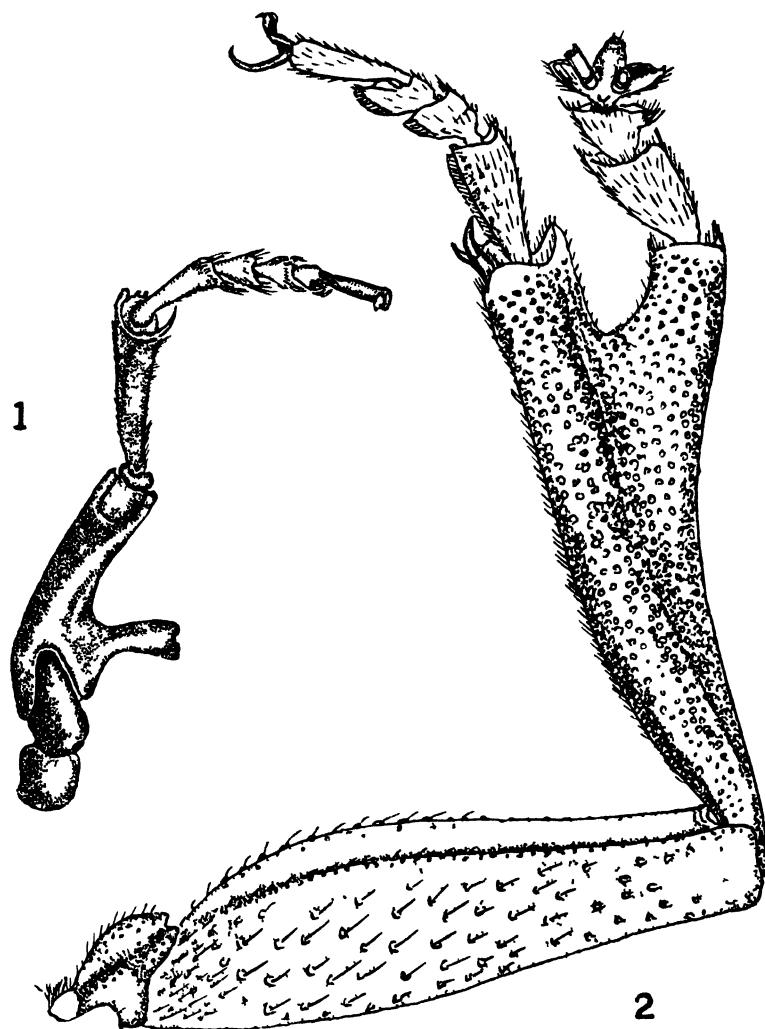
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Reduplication of legs in insects.



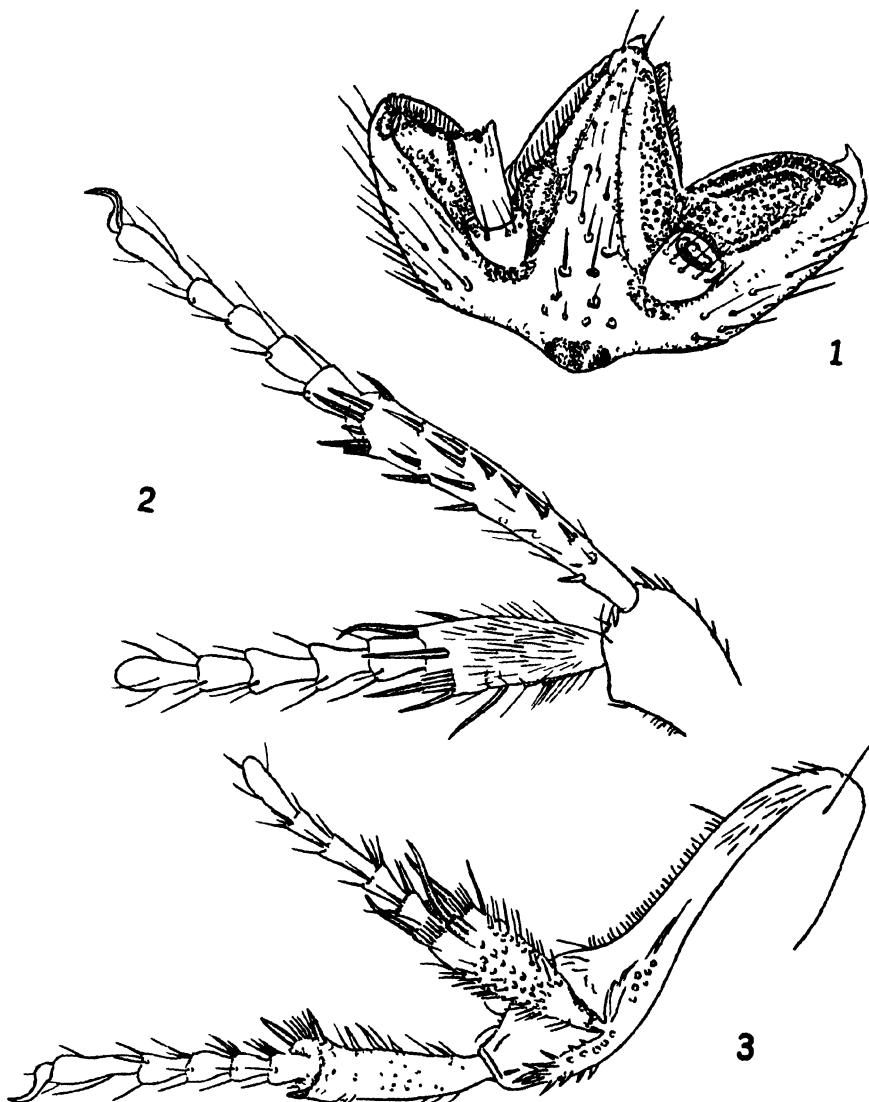
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Reduplication of legs in insects.



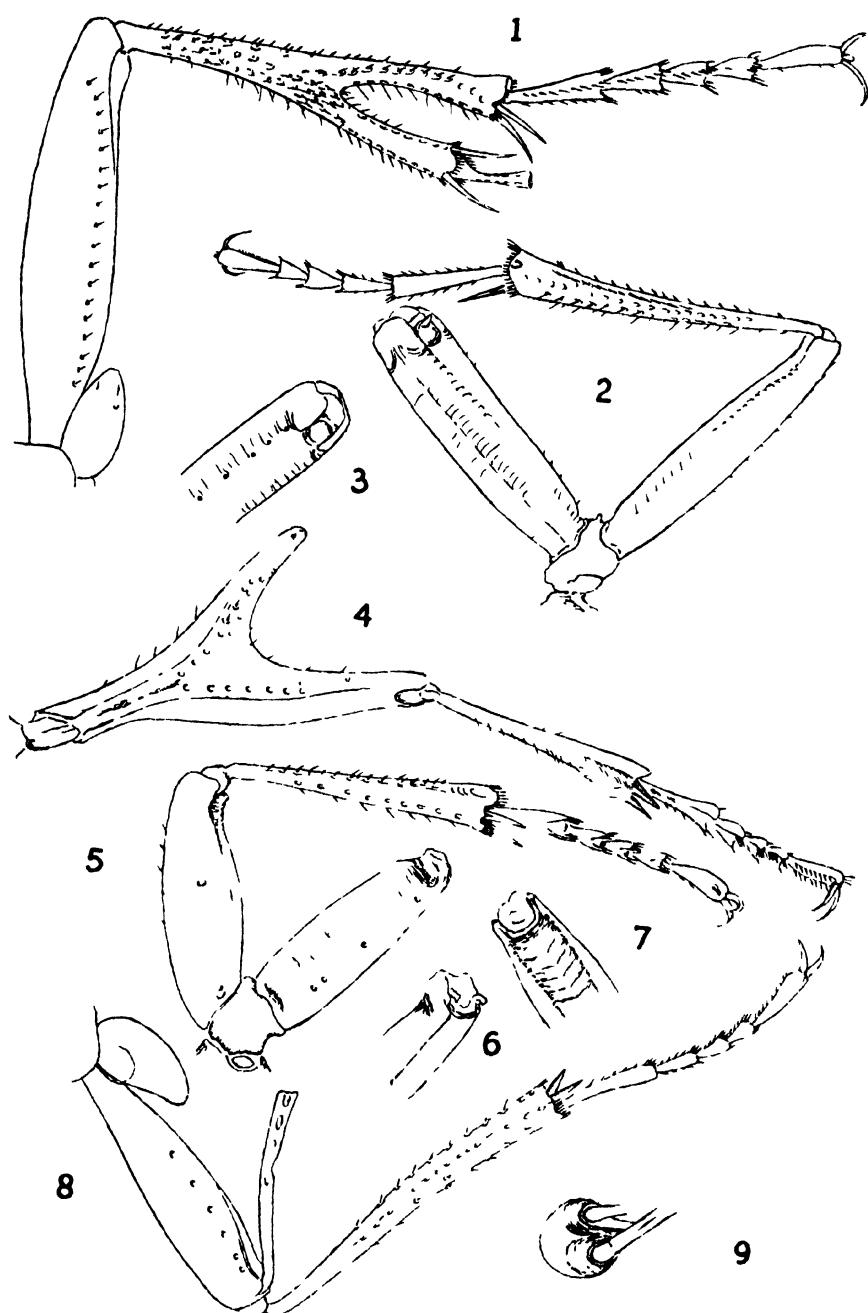
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Reduplication of legs in insects.



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Reduplication of legs in insects.



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Reduplication of legs in insects.

THE EARLY STAGES OF SOME AFRICAN LYCAENIDAE
(LEPIDOPTERA), WITH AN ACCOUNT OF THE LARVAL HABITS

By T. H. E. JACKSON, F.R.E.S.

(With an introduction by G. TALBOT, F.R.E.S.)

[Read 5th May, 1937.]

1. INTRODUCTION.

MR. JACKSON has asked me to communicate this paper to the Society, and it seems necessary to give some general idea of its scope including some bionomic notes communicated later by the author.

The fascinating theory of Mimicry, however one may regard it, as expounded by Sir Edward Poulton, has stimulated many young and able men in our colonies and elsewhere to investigate insect bionomics, and this has had important scientific results. Those who have come under his influence and shared his enthusiasm owe much to Poulton, and among them are the three investigators mentioned in this introduction.

It is well known that the larvae of many species of the family LYCAENIDAE pass their existence attended by ants, either within the ant nest or upon a plant frequented by ants. Our first information concerning these and other curious habits of the African species was due to Dr. W. Lamborn, who bred a great number of LYCAENIDAE in Southern Nigeria. His observations formed the subject of a brief communication to the Society by Dr. Lamborn and Professor Poulton in 1911, and were recorded in the *Proceedings* for that year; they were afterwards embodied in an important paper by Dr. Lamborn in the *Transactions* for 1913. The work was carried a stage further by the late C. O. Farquharson, also in S. Nigeria, who discovered that at least one species (*Lachnocnema bibulus*) fed upon living Membracids and Jassids. Farquharson's paper, with illustrations and descriptions by Dr. H. Eltringham, appeared in the *Transactions* for 1924.

These two pioneers in the bionomics of African LYCAENIDAE are now followed by T. H. E. Jackson, who, in Kenya and Uganda, has been breeding the species found there, and carefully recording his observations.

More exact knowledge of the early stages and larval habits of the Lycaenine species may help to show how far our generic distinctions hold good. Mr. Jackson finds, for instance, that the species known as *Phlyaria heritsia* and *P. cyara* are extremely different in their early stages, and to such a degree that he considers *heritsia* would be better placed near *Castalius margaritacea*.

Sets of the bred material, including ants, parasites, pupae, and larvae, have been presented by Mr. Jackson to the British Museum, and to the Hope Department of Entomology at Oxford.

I am responsible for checking the determinations of LYCAENIDAE. The ants were determined by Mr. H. St. J. K. Donisthorpe, and by Dr. F. Santschi of Kairouan, Tunisia. The Hymenopterous parasites were determined by Mr. J. F. Perkins.

Mr. Jackson desires to express his sincere gratitude to Sir Edward Poulton,
TRANS. R. ENT. SOC. LOND. 86. PART 12. (GEN.) (SEPT. 1937.) P

F.R.S., and to Professor G. D. Hale Carpenter, to whose help and encouragement he feels that he owes a great deal. It is also a pleasure for him to thank members of the Entomological Department of the British Museum, especially Mr. N. D. Riley (Keeper), and Messrs. H. St. J. K. Donisthorpe and J. F. Perkins, for their valued assistance.

Following is an account of the general bionomics of the LYCAENIDAE including notes by Mr. Jackson not given in the main body of the paper.

Ant Association.

Of the 58 LYCAENIDAE dealt with in this paper seven are so intimately associated with ants that they cannot live without them. These are *Liptena undina* S. & K., *Aphnaeus*, *Spindasis*, *Chloroselas*, *Anthene wilsoni* (Talb.), *A. levis grisea* (Talb.) and *A. nigeriae* (Auriv.). There are 25 other species which also possess tubercles and glands, and are therefore presumed to be ant-attended, although this was not always observed. These belong to the genera *Iridana*, *Deloneura*, *Deudorix*, *Virachola*, *Myrina*, *Axiocerses*, *Anthene* (= *Lycaenesthes*), *Phlyaria*, *Uranothauma*, *Castalius*, *Azanus*, *Syntarucus*, *Cosmolyce*, *Cyclirius* and *Euchrysops*. Among these genera are a few species in which neither tubercles nor glands are present, and such are not regarded as being ant-attended, even though the larva may live in the ants' nest.

Mr. Jackson believes that when a larva is merely attended by ants, the species of ant is immaterial. "With the leaf-eaters, where the attendant ant is possibly merely protective, I find that in each case any ant will do. I've tested them in pill-boxes and several species will drink from the gland, while in the field I've found different species actually in attendance in many cases. So that although some of my specimens have only one ant actually sent with them, it is probable that the other common ants also attend them."

The Larval Gland and Tubercles.

These organs are situated on the posterior segments and consist of a pair of minute eversible tubercles and a gland. The tubercles are placed on either side of and slightly posterior to the gland. Each tubercle is fine and thread-like and bears at its apex a rosette of minute spines which can be withdrawn into the stalk. When ants are present the tubercles are immediately protruded, and the ants are at once attracted to the spot. It is probable, therefore, that a scent is given off from the terminal spines, highly attractive to ants in order to bring them to the gland. "The organs vary in different species, both in themselves and in the manner of their use. In a few cases the gland is even a danger, as, if the secretion is not removed regularly, a mould appears and the larva soon dies. This may happen to *Anthene nigeriae* (Auriv.), and *Aphnaeus hutchinsoni drucei* Neave. The former species and the *Chloroselas* seem to carry a second gland under the collar between the second and third segments, and are protected here by hard chitinous plates."

Larval Habits and Food.

Mr. Jackson has discovered that one species (*Aslauga purpurascens* Holl.) feeds upon living Membracids, and that three species feed upon lichen. He also found that *Lachnocnema bibulus* (Fbr.) in this area did not eat Membracids but fed upon the secretion from their honey-gland, Jassids also being similarly

attended. In the case of species which spend the entire larval stage in the ants'-nest, the nature of the food taken has not been exactly ascertained. Mr. Jackson suggests, with much probability, that such larvae feed upon fungi cultivated by the ants; so far it has not been possible to prove that this is actually the case, and Mr. Jackson proposes to carry out some experiments to this end. The larva of *Spalgis lemolea* Druce feeds upon Coccids, and that of *Cyclirius* in a root below ground. Mr. Jackson notes: "Bark, lichen, the leaves, stems, fruit, and even the roots of plants of widely different groups are all utilised by members of the family, and no plant seems to be immune through thorns, poisonous juices, the hardness of its leaves, or through any other form of plant protection."

Larval Parasites.

"The LYCAENIDAE seem to be controlled by parasites neither more nor less than any other family, and while one species would appear to be almost immune one season, the next would see it heavily attacked. Most of these parasites are Hymenoptera. Their larvae are so small that the parasite goes on feeding into the pupal stage of the host and emerges from the perfect pupa. It is, therefore, a fairly safe test to collect many pupae and watch the results. In the case of *Spalgis lemolea* Druce no parasites emerged, and with *Aphnaeus hutchinsoni drucei* Neave no success has attended efforts to breed parasites in the tunnels of the ants, nor with *Anthene wilsoni* (Talb.) in the nests, both very good examples of the effectiveness of ant protection. With these exceptions all are equally attacked, although it would seem that flower feeders are more susceptible than fruit feeders, possibly because the female parasite would be normally attracted to the flowers for food. For several years small batches of the larvae of *Cacyreus lingeus* (Crm.) have been bred here, feeding on Labiates of many species and always on the flowers. In spite of their very wonderful protective colouring, of every shade of pink, purple and green, over 50 per cent. and sometimes as much as 90 per cent. are parasitised. It is quite obvious that without some form of protection, such as the above, a much harried species, like *C. lingeus*, would soon cease to exist. On the other hand, firstly, the example is one of the commonest species of the Labiatae, a very numerous order of plants in East Africa, largely protected from herbivorous animals by powerful and unpleasant scents; and secondly, almost every plant when examined will be found to bear eggs of the butterfly. It would appear, therefore, that some very efficient form of parasite would be necessary to keep the species under control."

Mr. Jackson sent to the British Museum a number of Hymenoptera and some Tachinid flies. Mr. Perkins has determined the former to belong to the genera *Charops*, *Anilastus*, *Neotypus*, *Mesochorus* and *Itoplectis* (ICHNEUMONIDAE), *Apanteles* (BRACONIDAE), and *Brachymeria*, and *Tetrastichus* (CHALCIDIDAE). These are noted with their respective hosts in the second part of the paper. As yet it has not been found possible to determine the Tachinids which were bred from 9 species, but the material is available for study at the British Museum.

The Pupal Stage.

"After many experiments carried out here, and the collecting of much data, it became apparent that no useful information would be gained by recording the time taken in the pupal stage of each species. It is entirely a question of weather, the deciding factor being probably the atmospheric humidity combined

with the temperature and light. During very dry weather emergence is retarded and only takes place after a shower of rain or if moisture is introduced into the breeding-cage. Given normal wet weather conditions, about 10-14 days is the usual period. The very critical stage in the life-history, when the wings are "growing" and drying after emergence, is in the LYCAENIDAE incredibly short. In 2 or 3 minutes after emergence the wings are fully expanded and the insect is ready for flight. Emergence takes place between 9 and 12 a.m., very seldom later than this, and usually between 9 and 10 a.m., in time, therefore, for the morning flight. With pupae in a breeding-cage indoors and not near a window, the time of emergence varies very little from that stated above, and it would seem from this, assuming the temperature of room and cage to be more constant than the open air, that light is the factor that governs emergence.

"In the case of *Stugeta olala* Stoneh. and *Argiolaus pallene* Wllgr. the time passed in the pupal stage is very long, as long as 6 months in some cases here. The reason probably is that both species inhabit very dry country where the veldt is burnt annually, thereby temporarily destroying the food-plant. It seems likely, therefore, that the insects remain in the pupa until the advent of the next rains when the food-plant is in foliage again."

Protection Against Ants.

Species which pass the larval stage within the nests of ants, and even emerge from a pupa formed there, require some protection from attack. One of these is *Anthene wilsoni* (Talb.), in which, strangely enough, neither tubercles nor gland are present. "The larva of this species relies entirely upon a thick leathery skin for protection. The imago, after emerging from the pupa, has to proceed to daylight along the ant tunnels, and the immunity which it enjoys from attack by the ants is probably due to the thick hair covering the legs and under parts of the body. Hair seems to be always a protection from ants, one very good example being the larva of *Deloneura ochrascens* (Neave). This larva is entirely clothed in spiny black hair, and its general appearance is very like that of many Lymantriid moths. The ants leave it entirely alone although it lives in and about the entrances of the tunnels and ant-runs."

Protective Coloration and Resemblance.

Larva.—"The larvae are often coloured to resemble the leaf on which they are feeding. *Anthene larydas* (Cram.) on *Albizia gummifera*, may be either green, red or pink, according to the colour of the foliage. *Anthene livida* (Trim.) feeds on the flowers of various species of *Kalanchoe* which may be either orange or yellow, and the larva is coloured accordingly. The larva of *Aslauga purpurascens* Holl. resembles lichen or moss, and that of *Cacyreus lingeus* (Cram.) resembles a Labiate flower. The larva of *Argiolaus silas crawshayi* Butl. is rendered practically invisible by a covering of down from the shoots of the food-plant in which it burrows."

Pupa.—"The pupa of *Epamera sidus* (Trim.) resembles the berry-like fruit of the food-plant, the resemblance being increased by a stalk-like attachment. The pupa of *Epamera tajoraca haemus* Talb. represents a piece of dead lichen-covered bark, sometimes black and sometimes with the grey-green mottling of lichen, and with all the irregularity of contour associated with dead twigs and bark. Such pupae are placed in exposed situations. Pupae which are without any special procrustis are invariably well hidden in seed pods, among

dead leaves or under bark. In the case of *Anthene wilsoni* (Talb.) which lives in the nests of ants, a cocoon is formed of the nest detritus cemented firmly together so as to be impenetrable to the ants. *Aphnaeus hutchinsoni drucei* Neave closes both ends of a tunnel in deadwood with hard ligneous material and pupates in the resultant chamber much as a Sesiid moth."

Imago.—Apart from the many well-known examples of mimetic resemblance and procryptic coloration furnished by the African LYCAENIDAE, one interesting fact may be mentioned here.

"It has been recorded by Farquharson and others that some species display false direction marks soon after emergence from the pupa. This is the case with most of the *Argiolus* and *Epamera* bred by me. Directly the wings are fully expanded the insect rests motionless with closed wings, the hind-wings carried well above the body. The tail appendages common to the genus are then displayed, the tails branching out diagonally from the wings and the basal lobes raised to a horizontal position below them on either side, forming a very good imitation of the head and antennae of the insect. If a predator appears before the wings are dry enough for flight, it may be puzzled as to which end to attack, and seizing the false head will merely tear away the anal part of the wing and the insect may escape."

2. DESCRIPTIONS AND HABITS.

(The number in parentheses following the name of each species is the original number applied to the specimens by Mr. Jackson.)

LIPTENINAE.

The following series (Nos. 1-6, 8, 9, and 11) are all to be found both in the larval and pupal stages on the trunks of trees. Some few are associated with ants, the majority for purposes of protection only, but others are probably more closely connected, living among the ants and feeding perhaps on fungi grown by their hosts; the greater part, however, are lichen feeders.

Many wonderful colour adaptations are present, some representing lichen and others the larvae of moths, etc., the former being procryptic and the latter in most cases aposematic since they mimic hairy stinging models. The whole life-history is passed on the bark.

The perfect insects are not uncommon in most cases, but, unless their habits are known, are seldom seen. They are very retiring in habit, flying early in the morning and again in the evening from 4 p.m. to 5 p.m. or during a dull afternoon when the females may be seen laying their eggs on dead twigs and trunks of trees. A favourite habit is to sit at the extreme end of a twig with wings folded, showing the usually procryptic underside, and they are often found feeding on secretions from plant glands on the young tendrils of creepers, etc., or among Membracids. Nearly all are mimetic of other insects, Acraeas, Pierines, etc. The ants concerned in all cases belong to a species of *Crematogaster*.

1. *Telipna consanguinea* Rebel (52).

Telipna consanguinea Rebel, 1914, *Ann. Hofmus. Wien*, 28 : 262, f. 39, 41.

Food. Lichens and mosses on the bark of trees, not among ants.

Larva. The larva is clothed sparsely with long brown hair and is indis-

tinguishable from that of a moth. It is broader anteriorly with a fine dark dorsal line and small black collar. The laterals are sharply scalloped, carrying tufts of short spiny hair, as well as the longer hair mentioned above. The colour is greenish or bluish-brown with fine darker lines and the anal segments black like the collar. Spiracles small and greenish, and below them a row of minute white dots. Head small and pale brown. Length, 30 mm.

Pupa. The pupa is placed with the extremity, surrounded by the larval skin, fixed to the trunk of the tree, standing out from it at an angle of 45°. It is quite unlike any other Lycaenid pupa I have yet seen, being similar to those of the NYMPHALIDAE, especially *Atella phalantha* (Drury). It is spiny, the spines being arranged in rows of rosettes laterally, ventrally and dorsally. Thorax sharply domed, the two sides of the dome bearing large oval spots, so highly polished as to resemble obsidian. Seen at certain angles they glitter and sparkle like eyes and at others suggest large holes in the thorax. The head-case is broad and carried well in front. Colour brown; wing-cases shiny; without spines. The pupa has no external protection whatsoever and, except that it is usually placed in a dark place behind a creeper, there is no attempt at concealment. Length, 16 mm.

Locality. Budongo Forest, Uganda.

2. *Telipna sanguinea depuncta* Talb. (53).

1937, *Trans. R. ent. Soc. Lond.*, 86: 59 (♂♀).

There is no apparent difference between the early stages of this and of the preceding species except that the larval hair is here more golden brown and slightly longer.

Locality. Budongo Forest, Uganda; also from Katera, Malabigambo Forest, about 10 miles from mouth of Kagera River, near the Tanganyika border, 4000 feet.

3. *Pentila muhata* Dew. (58).

Pentila muhata Dewitz, 1886, *Deuts. ent. Z.*, 1886: 428, t. 2, f. 6, 6a.—Aurivillius 1914, in Seitz, *Macrolep. World*, 13: 311, t. 61i.

Food. Lichens, preferring the smaller varieties on dead twigs and fallen log

Larva. In shape like a silver-fish (Thysanura), being broadly rounded anteriorly and tapering to a sharply pointed posterior extremity. Each segment carries three or four black spines. Dorsum irregularly rounded and head protected by a collar from which it is never extruded even when feeding. In colour green, grey and black exactly resembling the lichen on the tree. Length 15 mm.

Pupa. As in the larval stage spiny, although here the spines are single and whitish and arranged in rows of five across each segment. The head case is black with prominent white eye-spots; the thorax small, but elevated, and beyond it a depression, and up to this point the colour is light brown. Thereafter the abdominal segments are on a higher level, roughly rounded and broader, coloured pale green. The larval skin is placed around the extremity in a small, bunched up, spiny circle. Wing-cases jet black; placed in a horizontal, arched position on the bark. Length, 8 mm.

Locality. Budongo Forest, Uganda.

4. *Mimacraea krausei poultoni* Neave (55).

Mimacraea poultoni Neave, 1904, *Nov. Zool.*, 11 : 337, pl. I, f. 18.—Aurivillius, 1918, *in Seitz Macrolep. World*, 13 : 316.

I am unable to discover any differences whatever between the larva and pupa of this form and the form *masindae* B.-B.

Egg. Circular, hemispherical, and dirty yellowish-white with the surface minutely ornamented with a network pattern and a small black central spot. Laid among lichen on bark. Very small for the size of the insect: diameter, 0.5 mm.

Locality. Busia, Uganda.

5. *Mimacraea krausei masindae* B.-B. (54).

Mimacraea masindae Beth.-Baker, 1913, *Ann. Mag. nat. Hist.* (8) 11 : 565 (Budongo Forest).—Aurivillius, 1918, *in Seitz Macrolep. World*, 13 : 317.

Food. As in the case of the two species of *Telipna*, the larva feeds on lichens and moss on the trunks of trees and is not found among ants.

Larva. The larva is dark sepia brown, almost black with long blackish hair, sparsely covering it and allowing the shiny skin and segment rings to appear. Head very small and unprotected, the whole moth-like and very like the larvae of some Lithosiids. Length, 26 mm.

Pupa. Placed flat on the bark, the larval skin enfolding the last few segments; usually among moss. It is dark blackish-brown with short thick hair carried transversely across each segment, the divisions being free and an occasional longer hair here and there. It is capable of movement from side to side. Very broad, but without irregularities. Length, 17 mm.; breadth, 7 mm.

Locality. Budongo Forest, Uganda.

6. *Liptena undina* Smith & Kby. (57).

Liptena undina Smith & Kirby, 1894, *Rhop. Exot.*, 29, Lycaen. Afr. : 117, pl. 25, f. 6, 7.—Aurivillius, 1918, *in Seitz Macrolep. World*, 13 : 334, t. 63k.

Food. The larva is very closely associated with ants and will not feed up in captivity.

Larva. The larva is small, regularly formed dark sepia and hairy, each hair terminating in a white, bulbous filament. Head very small, but unprotected by a collar. Length, 11 mm.

Pupa. As in the larva dark brown, with the same brown, white-tipped hair. It is well hidden under bark and near the ant-runs. Length, 9 mm.

Locality. Budongo Forest, Uganda.

7. *Aslauga purpurascens* Holl. (36).

Aslauga purpurascens Holland, 1890, *Psyche* 5 : 424.—Aurivillius, 1920, *in Seitz Macrolep. World*, 13 : 343, t. 64c.

Food-plant. Usually found in my experience on *Acacia stenocarpa* Hochst., Mimosaceae, where it feeds on Membracids. Being carnivorous it is not easy to breed in captivity, and if at all starved will devour other larvae of the same or similar species such as *L. bibulus* F. When catching a Membracid it will move quietly nearer until close enough, when the anterior portion of the carapace is slightly raised and lowered again over the victim.

Egg. The egg is laid flat on the leaflets at the extreme tips of the branches

near a colony of Membracids. It is very small, white, and oval with slight central depression less than 0.5 mm. long.

Larva. In shape something like a limpet shell, and coloured in mottled greys and greens to represent lichen or moss on bark. The skin is rough and leathery, the carapace being extraordinarily heavy, completely protecting the legs, head and ventral portion. The outline of the carapace is nearly oval with slight central indentations; from here on all sides, especially from the front, it slopes very abruptly upwards to a broad dorsal ridge, 2.5 mm. in breadth and centrally depressed. At the extreme posterior end of the ridge are two small external tubercles. The head is small and black, and is protruded when feeding or moving from under the carapace similar to that of a tortoise. I have never seen the tubercles exserted.

Pupa. The pupa is brown mottled with black and is placed flat on bark or under it, and attached by the posterior extremity. The abdominal segments are very broad and contracted, sloping very sharply to the posterior extremity and more gradually to the head case. Thorax slightly ridged and shoulders rather prominent, the pupa as a whole being squat and roughly oval in outline. At each extremity low down on the lateral surfaces are small depressions one on each side like eye-spots, and coloured black which, together with a small black line above the head case and a black spot in the centre of the posterior stalk, gives a very good impression of another insect when looked at from above.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, March, 1933.

8. *Iridana incredibilis* Stgr. (51).

Iridana incredibilis Staudinger, 1891, Deuts. ent. Z. 'Iris,' 4 : 141.—Aurivillius, 1920, in Seitz *Macrolep. World*, 13 : 345, t. 65c.

Early stages : Farquharson, 1921, *Trans. ent. Soc. Lond.*, 1921 : 357-358 (larva on *Alstonia congensis*).—Eltringham, 1921, *Trans. ent. Soc. Lond.*, 1921 : 477, pl. XII, f. 6, 10 (pupa) (S. Nigeria).

Food. In habits it is similar to *I. marina*, but it spins a thick white covering quite unlike the other as protection from attacks by ants.

Larva. Very like that of *I. marina*, but lacking the french-grey ground-colour, which is here duller and blacker; otherwise it does not differ.

Pupa. The pupa on the other hand is very different. It is placed in its thick white puparium, right in the ant-runs in a crack of the bark. Brown, with broad domed thorax covered in short fine hair, abdominal segments regularly formed. The larval skin is curled up over the extremity. Length, 11-12 mm.

Locality. Busia, Uganda.

9. *Iridana perdita marina* Talbot (50).

Iridana perdita marina Talbot, 1935, *Ent. mon. Mag.*, 71 : 74 (Uganda).

Food-plant. The larva probably feeds on lichens among ants, apparently at night, since by day it is found with a light silken covering over it, in a crack of the bark. It was raised in captivity without ants.

Larva. Hairy and very moth-like. It is coloured french grey with three dark brown transverse bars, one centrally and one at each extremity, and in addition the posterior half has a dark, broad dorsal line. The extreme lateral edges are whitish, above which is a broad, greyish-black longitudinal line, followed by french grey, and there is a suggestion of orange-brown at the base of the hair. The whole clothed in long greyish hair. Length, 21 mm.

Pupa. Enclosed in the same thin silken covering as used by the larva;

it is placed among moss or lichen, near the ant run. The pupa itself is brown and hairy, the hair along the laterals being arranged in thick symmetrical tufts. Thorax small and oval, followed by a waist; the abdominal segments being also oval it resembles a badly formed figure 8. The hairy larval skin is arranged in a long untidy rosette around the posterior extremity. Length, 11 mm.

Locality. Budongo Forest, Uganda.

10. *Deloneura ochrascens* (Neave) (35).

Poultonia ochrascens Neave, 1904, *Nov. Zool.*, 11 : 336, pl. I, f. 13.—*Deloneura ochrascens*. Aurivillius, 1920, in *Seitz Macrolep. World*, 13 : 347.

Food-plant. The larva is found on the bark of *Acacia stenocarpa* Hochst., Mimosaceae, among ants.

Egg. The egg is a most complicated object. It is large, fully 1 mm. in diameter, circular, and much flattened. It consists of a flat outer ring embossed with symmetrical rays, and a slightly elevated circular inner portion with a small black central spot. It is stone grey or brownish-grey, and is laid singly among the lichen or in the fissures of the bark.

Larva. Black, with very long black hair, strongly reminiscent of the larvae of certain Lymantriids. In the early stages the dorsum is lighter, mottled and streaked with black, with broad black bars on segments 2, 4 and 10. Head small and black, thoracic segments somewhat broader, tapering thence to the anal extremity, with long lateral fringes of hair. Tubercles and gland not present. Length, 25 mm.

Pupa. The pupa is placed usually on the outside of the bark or in cracks, fissures, etc.; it is cryptically coloured in black or grey. The posterior portion is surrounded ventrally by a rosette of long blackish hair, being the old larval skin, the pupa itself being also hairy. In shape, starting from the posterior extremity, it becomes gradually broader with a broad dorsal ridge and three lateral wart-like processes: about the centre of the wing-cases is a "waist" more prominent dorsally than laterally. Head-case very prominent with a dorsal ridge. There is a heavy black dorsal line and a jet black transverse streak across the first abdominal segment. It is placed flat on the bark and attached by the posterior extremity to a silk-covered patch.

Note on possible food. The larva is found sometimes near the entrances of the ant tunnels or sometimes in a crack of the bark, but always close to or among the ants. Bark is probably eaten, but it will not feed up on this in captivity. Nevertheless, it still seems the most likely food, and possibly some small fungus or lichen on the bark is sought after. The larva takes no notice of the ants, nor they of it, in fact the ants appear deliberately to avoid it. An examination of the mouth-parts and of the excreta might help to determine what its probable food is.

The ant associated is *Crematogaster (Acrocoelia) castanea* Smith var. *tricolor* Gerst.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, Sept., 1932.

11. *Hewitsonia kirbyi intermedia* J. & T. (56).

Hewitsonia kirbyi intermedia, Joicey & Talbot, 1921, *Bull. Hill. Mus.*, 1 : 86, ♀ (Ituri).—Hawker-Smith, 1928, *Rev. Zool. Afr.*, 16 : 215, ♂ (Congo).

Food. Lichen on the trunks of trees, preferring apparently the smaller types, since it is found usually on clean smooth bark where its coloration is very effective.

Larva. The larva resembles the larva of certain Lymantriids, and both can usually be found on the same tree, so that it requires quite a close examination to distinguish the two. It is whitish and light brown with a complicated diamond-chain design on the dorsum. Broader anteriorly, but tapering only slightly from here. The dorsum is smooth, but the sides and extremities are fringed with long fine hair, spread horizontally on all sides, and interspersed at each segment with thicker shorter filaments of a light brown silky appearance. Head large, black and unprotected. Length, 30 mm. and over.

Pupa. Flat on the bark, and unprotected except for its procryptic colouring, placed usually behind creepers or beneath an overhanging log. It is attached by the posterior extremity with the hairy larval skin arranged in a neat flat rosette around it. The abdominal segments are broad and shield-shaped, slightly ridged dorsally and spiny, especially along the lateral edges, thence with deeply incised shoulders and a broad and domed thorax. The head-case is protected by a broad shovel-shaped collar above, the actual appendages being carried ventrally and completely hidden. Wing-cases also ventral or nearly so, and smooth. The colouring is lichen-like in greys and greens with black speckling. Length, 17 mm.; breadth, 9 mm.

Locality. Budongo Forest, Uganda.

LYCAENINAE.

12. *Lachnocnema bibulus* (F.) (42).

Papilio bibulus Fabricius, 1793, *Ent. Syst.*, 3 (1) : 307.—*Lachnocnema bibulus* Aurivillius, 1923, in Seitz *Macrolep. World*, 18 : 383, t. 65g.

Early stages : Farquharson, 1921, *Trans. ent. Soc. Lond.*, 1921 : 388 (larva feeding on secretion of immature ant-attended Membracids, and on living Membracids and Jassids).—Eltringham, 1921, *Trans. ent. Soc. Lond.*, 1921 : 483, pl. XIII, f. 21 (pupa) (S. Nigeria).—Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 470 (larval habits) (S. Nigeria).

Food-plants. It is found on many species of tree or shrub, in fact wherever Membracids or Jassids are present. The larva feeds on the secretion provided by the immature stages of the above, and the process is interesting. The fore-legs are much modified, being long, crab-like and capable of extended movement. Sitting back on its abdominal segments, the forepart of the body is raised over the anal tube of the Membracid, the fore-legs are then vibrated rapidly over the insect, just in the same way as an ant strokes certain larvae with its antennae, when a drop of the secretion promptly appears and is greedily devoured. I have never seen a Membracid actually eaten.

Egg. The eggs are orange when freshly laid, small, circular, flattened, and strongly indented centrally above. They are laid among colonies of Membracids or Jassids but not in my experience among Coccids, the ♀ often pausing with abdomen raised away from the ants to feed on the secretion left on the stems or leaves.

Larva. The larva is first red with black head, later brown. The dorsum is curved evenly from the anal extremity upwards and then down again, the head centrally very broad. Both collar and lateral carapace are present, the latter having scalloped edges. Dorsally there are rows of warts carrying long hair. Head black and small.

Pupa. I have not seen the pupa of this species.

Parasites. A Tachinid was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6–7000 feet, March, 1930.

Ants. The following ants were sent with this species, though their relation to the Lycaenid is not mentioned by Mr. Jackson [G.T.]. *Crematogaster*

(*Sphaerocrema*) *phoenix* Sants.; *Crematogaster* (*Acrocoelia*) *castanea* Smith, st. *inversa* For. var. *elonga* Sants.; *Cataulacus donisthorpi* Sants.; *Myrmicaria opaciventris* Em. var. *obscuripes* Sants.

13. *Deudorix dinochares* Gr. Sm. (46).

Deudorix dinochares Grose Smith, 1887, *Ann. Mag. nat. Hist.* (5) 19 : 64.—Aurivillius, 1921, in *Seitz Macrolep. World*, 13 : 374, t. 66d.

Food-plant. The larva feeds on the fruit of *Syzygium cordatum* Hochst., ex Harv., Myrtaceae. It bores inside the fruit and emerges only to pupate or when the fruit is a mere hollow shell.

Egg. The egg is laid in the depression in the top of the fruit; it is large, fully 1 mm. in diameter, and white. In shape, it is circular at base and evenly domed, with no central depression.

Larva. The larva is very similar to that of *Deudorix antalus*, being bluish-grey, with the warts present as in that species.

Pupa. The pupa also is like that of *D. antalus*. As in the case of the larva, it is practically indistinguishable and neither require further description.

Parasites. Two species of *Neotypus* (Hymen., ICHNEUMONIDAE) were bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, June, 1934.

14. *Deudorix antalus* Hpffr. (41).

Deudorix antalus Hopffer, 1855, *MonBl. Akad. Wiss. Berl.* 1855 : 641.—Aurivillius, 1921, in *Seitz Macrolep. World*, 13 : 375, t. 66e.

Food-plant. The larva feeds in the seed pods on the immature seed of *Acacia stenocarpa* Hochst., Mimosaceae; also in pods of *Dolichos lablab* (Linn.), Papilionaceae.

Egg. The eggs are a beautiful clear pale green, circular at the base, about 0.5 mm. in diameter, evenly domed and with a small dark central spot. They are laid near the junction of the seed pods and their stalks, either singly or in pairs.

Larva. The larva is chocolate brown with longitudinal rows of black warts carrying indigo blue hair, one row along the dorsum and two along each lateral. The collar is larger than usual, since both the first and second segments are broadened and hood-like and spotted with indigo and yellow. The shape is grub-like, broad and rounded dorsally, the head small and black. The anal segments are flattened and hairy; they possess two minute white tubercles placed close together with the gland centrally above them. Length, 20 mm.

Pupa. The pupa is placed among the bark, in cracks or under loose pieces, and fastened by a silk sling. It is dark brown with black dorsal line and wing-cases, of nearly even width throughout, broader than usual, with more prominent head-case and a slight "waist" midway. Length, 10 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, April, 1933.

15. *Virachola jacksoni* Talbot (15).

Virachola jacksoni Talbot, 1935, *Ent. mon. Mag.*, 71 : 206, pl. IV, f. 2, 3 (Uganda, Kenya).

Food-plant. The larva feeds on the young leaves of *Loranthus usuiensis* Oliv., Loranthaceae.

Egg. Not known.

Larva. The larva is dark rich brown, with a patch on the dorsal region

of segments 2 and 3 much lighter brown, surrounded by a square of black. It is covered with short black spiny hair. The segments are strongly incised, and along the sides are rows of deep, pit-like depressions. The shape is slug-like, tapering from the centre to both extremities, the dorsal region being broad but not markedly ridged. Collar heavy, and spiracles plainly visible and black. Thin, short tubercles are present on the anal segments, half-way between the centre and the edges; they are exserted vertically, and above them is a gland with an oval deep-seated orifice. Length, 20 mm.; breadth, 6 mm.

Pupa. The pupa is broad and foreshortened, brown with a black dorsal line and heavy black lateral markings. Head-case broad and rounded, thorax also broad and evenly curved, with a slight depression between it and the abdominal segments. It is placed flat on a leaf, the surface of which has been previously cleaned and smoothed, and another leaf drawn down over the top by silk threads. Length, 10 mm.; breadth, 6 mm.

Parasites. *Tetrastichus sculpturatus* Waterst. (Hymen., CHALCIDIDAE) was bred.

Locality. Kenya : Trans Nzoia, August, 1933.

16. *Myrina silenus* (F.) (33).

Papilio silenus Fabricius, 1775, *Syst. Ent.* : 531.—*Myrina silenus* Aurivillius, 1922, in Seitz *Macrolep. World*, 13 : 378, t. 68a.

Early stages : Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 472 (ant-attended larva) (S. Nigeria).—Lamborn and Poulton, 1911, *Proc. ent. Soc. Lond.*, 1911 : xcix-c.

Food-plant. The larva feeds on the young shoots of *Ficus ingens* Miq., Moraceae, and other figs.

Egg. The egg is circular and white, with a pretty network pattern over the surface. It is evenly domed, with a small central black spot. More than 1 mm. in diameter. It is laid on the tips of the unopened shoots.

Larva. About 1.5–2 mm. long on emergence, it is posteriorly yellowish-green and anteriorly brown. The dorsum is at first flattened, rising at segment 4 to a hump, then of even height, and corrugate to the ninth segment, finally a broad shield as at the posterior extremity. Segments 4, 8, and 9 are larger and thicker than the rest and reddish-brown. When full grown the ground-colour is green, the intersegmental regions deeply incised, each individual segment being triangular with the exception of the three thoracic ones, which are square and double ridged. Segment 4 is large, triangular, and red; segment 7 smaller, but also red; segments 8 and 9 very much enlarged, the former white, the latter green, and both powdered with minute black spots. Head small and black, carapace heavy but not as adequate as usual. Laterally on segments 9 and 10 are respectively, large red and white spots. The anal segments are flattened and truncate, possessing tubercles and gland. The tubercles are blunt thick yellowish structures which are exserted at a slight angle outwards from the vertical, but are not oscillated. They are placed just below the gland and close to each other; the gland is situated centrally above them and has a large pinkish oval orifice. Length, 25 mm.

Pupa. The pupa is dull brownish-green, broad, blunt, and much contracted. It is "waisted" laterally and dorsally between the thoracic and abdominal segments. The thorax is ridged, curving evenly to the head-case, the width being much the same throughout, although slightly wider at the wing-cases and thence tapering in both directions. Between the green wing-

cases and the thorax are some white markings; dorsal line dark sepia reaching only to the thorax, head-cases very blunt. Length, 20 mm.; breadth, 8 mm.

Parasites. Four species of *Neotyphus* (Hymen., ICHNEUMONIDAE) were bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, Sept., 1933.

17. *Hypolycaena philippus* (Fabr.) (48).

Papilio philippus Fabricius, 1793, *Ent. Syst.*, 3 (1) : 283.—*Hypolycaena philippus* Aurivillius, 1922, in Seitz *Macrolep. World*, 13 : 384, t. 67a.

Early stages: Lamborn and Poulton, 1911, *Proc. ent. Soc. Lond.*, 1911 : c-cii.—Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 474 (ant-attended larva) (S. Nigeria).

Food-plant. The larva feeds on the seed capsules and leaves of *Ximenia americana* Linn., Oleaceae.

Egg. White, circular and domed, with a prominent black central spot; the surface ornamented with a deeply cut reticulated pattern. Diameter, 0.5 mm. It is laid on or near the small seed capsules.

Larva. Clear dark green and immaculate, with smooth velvety skin and segment divisions sharply defined, but not incised. The margins are slightly scalloped and are fringed with short brownish hair. In shape regular, barely narrowing at the extremities and much like some species of typical LYCAENINAE. Collar broad, rounded and paler green. There is a distinct gland, fringed with short brown hair and having a dark oval orifice; there are apparently no tubercles which, if true, is most unusual. Length, 17 mm.; breadth, 4 mm.

Pupa. The pupa is dark green with a few lighter chalky markings and a fine pale dorsal line. It is regular in shape and rather like an *Anthonome* pupa, but broader than most. Thorax ridged with a slight central depression between it and the abdominal segments. Length, 8 mm.; breadth, 5 mm.

Locality. North Kavirondo: Kitosh, slopes of Mt. Elgon, about 5,500 feet, May, 1934.

18. *Stugeta olalae* Stoneh. (49).

Stugeta olalae Stoncham, 1933, *Bull. Stoneham Mus.*, 17 : 2 (Kenya).

Food-plant. The larva feeds on the leaves of *Ximenia americana* Linn., Oleaceae.

Egg. Greyish-white. It is circular and domed, not flattened above, but with a small black central spot. The texture of the shell is like velvet. It is laid on the uppersides of the leaves. Diameter, 0.75 mm.

Larva. Until nearly full grown the larva is green with red spots on the knife-like dorsal ridge. Later, however, when nearing pupation, the extremities are dull brownish-green to black, and the whole central portion chalky white. The skin is polished and semi-translucent, but deeply pitted and uneven, with the segment divisions deeply incised. Carapace broad and well developed with scalloped edges. The dorsal ridge rises abruptly from the head, curving over in a series of roughly pointed processes to the flattened anal segments. Both the collar and anal extremity are bifurcate, the former bluntly, the latter very sharply so, with the central portion of the former depressed and carrying a rounded highly polished central spot. The lateral margins have two very broad wing-like processes between segments 4 and 5, and slope away evenly from these in both directions. There appear to be neither tubercles nor gland, and no ants were in attendance. Length, 20 mm.

Pupa. The pupa is very strangely formed. The colour dirty grey to brownish-white with darker markings and four black streaks, resembling "eye-spots," especially the anterior pair, placed just below the central dorsal

ridge on either side. Starting at the posterior extremity, there is firstly a very long narrow stalk, fully 5 mm. long, more or less flattened above, becoming gradually broader until it meets the wing-cases; here dorsally, above the centre of the wing-cases, is a large double hook-like process raised about 2 mm. above the general level, the anterior of the pair being larger and higher. Following on this is a deeply curved depression, and finally the broadly humped thorax, sloping abruptly to the head-case. Ventrally the wing-cases stretch over the whole length except for the stalk. The pupa stands out at an angle from the stem of the food-plant with no support except for the extremity of the stalk, and is jointed at the junction of this with the main body. Length, 15 mm.; breadth, 5 mm.

Locality. N. Kavirondo : Kitosh, slopes of Mt. Elgon, about 5,500 feet. September, 1935.

19. *Argiolaus silas crawshayi* (Btlr.) (12).

Iolaus crawshayi Butler, 1900, Proc. zool. Soc. Lond., 1900 : 926.—*Iolaus silas crawshayi* Auri-villius, 1923, in Seitz Macrolep. World, 13 : 396, t. 68b.

Food-plant. The larva feeds on the young leaves of *Loranthus usuiensis* Oliv. and *Loranthus Dregei* E. & Z., Loranthaceae.

Egg. White, circular at base, domed, with a slight central depression. Diameter, about 1 mm. It is laid singly on the undersides of the leaves, or on the tips of the new shoots.

Larva. The larva is very minute when freshly emerged and feeds up comparatively slowly. It is dull dirty whitish-green or brown, and hairy; the hair collects the loose dusty covering of the young leaves, rendering it practically invisible until almost full grown. In the last stage it is green, leaves the very young shoots, and feeds along the edges of the larger leaves. Here it contrives to fill up the resultant gap between itself and the leaf, the knife-edged dorsal ridge forming a very good imitation of the edge of the leaf, making it again very difficult to detect. It is slug-like, the cross-section being triangular. The first three segments are broad, rising abruptly to the highest point of the dorsum at segment 3, gradually tapering from there to a point at the anal extremity; this latter is sharply bifurcate. The dorsal ridge is knife-edged, the skin rough and carrying very fine short hair. Carapace broad and adequate, completely protecting the legs. There is no sign of either tubercles or gland, and no ants seem to be in attendance. Length, 25 mm.

Pupa. Silk is spun over the surface of a leaf and the pupa is attached to this by its posterior extremity, the abdominal segments being arched over to the head-case which rests on the leaf. It is green with a row of brown dorsal spots. The thorax is bluntly ridged and is followed by a depression, then a large hump at the beginning of the abdominal segments, and finally tapers sharply to the posterior extremity, which is stalk-like and jointed. When alarmed the pupa will hammer rapidly on the leaf with its head-case, making quite sufficient noise to frighten away a small predator. Length, 15 mm.

Parasites. A species of Tachinid was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, October, 1932.

20. *Epameria bansana yalae* Rly. (11).

Epameria bansana yalae Riley, 1928, Nov. Zool., 34 : 385, pls. X, XI, f. 17 (♂), 18 (♀) (Kenya).

Food-plant. The larva feeds on *Loranthus woodfordioides* Schweinf., Loranthaceae, chiefly on the flowers when these are present, and it is coloured

pink or reddish to resemble them; when no flowers are present, it feeds on the leaves, and is then green.

Egg. White, circular and slightly domed, with a pretty network pattern. Diameter, about 0.5 mm. It is laid amongst the flowers, on or under the leaves, or on the stems, rather indiscriminately, singly or in pairs.

Larva. The larva is very strangely shaped. Seen from above, the outline across the head is square, running from here in straight lines to the widest part at segment 3, then tapering, again in straight lines, to the anal segments, where there are two fin-like lateral processes, and finally terminating at the anal extremity in a point. The dorsum is coloured lighter as a rule, with dark patches on segments 2, 3, 10, and 11, but the colouring, as stated above, is very variable, being merely procryptic in design. In profile the dorsum drops vertically to the head. Sometimes the lateral anal "fins" are white, as also the point of greatest width at segment 3. There are apparently neither tubercles nor gland. Length 12 mm.

Pupa. The pupa is pinkish-brown, the anterior half being darker with a pink spot at the apex of the thorax. The head-case is blunt, the thorax rising abruptly from it, slightly "waisted" beyond, then rising again to a ridge running transversely across the origin of the abdominal segments. The latter are here broad and flattened, with (on either side behind the ridge) a pit or depression, and above these on the dorsum a jet-black spot. The posterior extremity is tapered and stalk-like, and is attached to a stem or among the flower clusters. Length, 11 mm.; breadth, 5 mm.

Locality. Mt. Elgon.

21. *Epamera sidus* (Trim.) (14).

Iolaus sidus Trimen, 1864, *Trans. ent. Soc. Lond.*, (3) 2: 176.—*Epamera sidus* Aurivillius, 1924, in Seitz *Macrolep. World*, 13: 402, t. 68h.

Food-plant. *Loranthus woodfordioides* Schweinf., Loranthaceae, is eaten, the larva feeding on the leaves or young flower-buds, but not as a rule on the flowers after they have opened.

Egg. The eggs are laid on the upper- or undersides of the leaves, on the buds, stems, etc., without any apparent effort at concealment. They are yellow, circular and domed, with a complicated embossed pattern covering the surface. Diameter, about 0.5 mm.

Larva. The larva is very strangely formed. Green or greyish-green with a large whitish triangular spot filling up the central depression. Beginning at the anal extremity and arising from the last four segments there is a large tent-like process ending in a curved and sharply pointed spike; following this is a deep valley, the bottom of which is only 3 mm. in total thickness. Finally the dorsum rises again to a curved knife-edged ridge extending over three-quarters of the total length, and from this falling almost vertically to the head. At the highest point of this anterior dorsal ridge, the depth is 6 mm. There are apparently neither tubercles nor gland, although the carapace is more than adequate for protection against ants. Length, 15 mm.

Pupa. Resembles a seed capsule of the plant. The posterior segments are contracted into a thin stalk which is fixed to a twig, and are articulated so that the head-case can be hammered against the surface of the twig when an enemy comes too close. The whole pupa is so contracted that the overall length is only 6-7 mm. The dorsum is rounded, the thorax slightly ridged, and in

general the shape is semispherical and strongly reminiscent of a berry. It is green with the exception of a large sepia brown patch on the thorax.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, Jan., 1932, and April, 1931.

22. *Epamera tajoraca haemus* Talbot (13).

Epamera tajoraca haemus Talbot, 1935, *Ent. mon. Mag.*, 71 : 118, pl. 2, f. 2, pl. 3, f. 17 (Kenya).

Food-plant. The larva feeds chiefly on the unopened flower-buds, but also on the leaves of *Loranthus curviflorus* Benth., Loranthaceae.

Egg. Pure white and shaped like an inverted saucer with a flat base. The surface carries a heavily indented network pattern visible to the naked eye. As with all Lycaenids, the young larva emerges from a neatly cut circular hole in the centre of the top of the egg. The egg is laid on the upper or under surfaces of the leaves, singly or in pairs. Diameter, 0.5 mm.

Larva. When freshly emerged very pale greenish-olive with a darker dorsal line. The dorsum is fin-like and drops very abruptly to the head, rising at first in the other direction to the highest point on segments 4 and 5; it then tapers gradually to the anal extremity. Looked at from above it is centrally broad; starting from the head it reaches its maximum width at segments 4 and 5, and again tapers as far as the last four segments, which are narrow but of almost equal width. There are three light coloured spots on the sides and the segment rings are deeply corrugate. When full grown the colour changes to grey, with black dorsal spots. Neither tubercles nor gland are present. Length, 20 mm.

Pupa. Very dark, mottled black or brown, resembling closely the rough gall-like nodes on the stems of the food-plant, sometimes with green markings like lichen. Seen from above the posterior extremity is stalk-like and attached as a stalk flat on to a twig. It widens gradually to the centre of the wing-cases, beyond which there is a "waist"; then there are slight central projections of the thorax, and thence to the head-case it is narrow and short. The latter is blunt, but bilobed, in profile slightly upturned; the thorax domed but very irregular, and between it and the abdominal segments is a very deep depression. The abdominal segments being the highest point, start well above this depression and curve over and down sharply to the stalk. The segment rings are well defined as in the larval stage. Length, 10-12 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, October, 1933.

23. *Aphnaeus hutchinsoni drucei* Neave (37).

Aphnaeus drucei Neave, 1904, *Nov. Zool.*, 11 : 338, pl. I, f. 6.—*Aphnaeus hutchinsoni drucei* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 409.

Food-plant. The larva is found on *Acacia stenocarpa* Hochst., Mimosaceae, also on *Entada abyssinica* Stend., Mimosaceae, and on certain species of *Loranthus*, but always where a nest of ants is present.

Egg. The egg is grey to black, the surface heavily and symmetrically pitted. Circular at base, the walls rise vertically to a rounded top, 1 mm. in diameter. It is laid singly on the twigs of the tree where the bark is old enough to have become lignified, and is even laid on dead branches.

Larva. Light greenish when young, later changing to dark brown and when full grown it is dull purplish-grey. The head is very large, dull brown, with a sharply ridged collar. Segments very clearly defined and deeply incised; it is dorsally flattened, the sides falling away vertically from the ridged edges

of the dorsum so that a cross-section would be square. The larva, when half grown, is covered with short hair especially laterally, and has a black dorsal line which disappears later leaving only small lateral fringes of hair. The anal segments are flattened and posteriorly rounded, segment 11 being laterally enlarged with a transverse ridge across it, carrying at each extremity a prominent brown external tubercle. The actual organs are short thick whitish structures which are continuously and very rapidly exserted and retracted in the presence of ants. The larva bores into the smaller branches, leaving large circular burrows in one of which it pupates. Ants are constantly in attendance, and are in fact essential to its life, for if they are removed the tubercles and gland gradually grow mould and the larva dies. Length, 30 mm.

Pupa. The pupa is placed inside one of the excavated tunnels. First, the surface of the tunnel is lined with silk, then both ends are sealed with thickly spun silk wads, leaving an enclosed area roughly 1½ in. long, inside which to pupate in complete seclusion from ants. The pupa is long and narrow, the abdominal segments being rather prominent and doubled back at the posterior extremity to form a short stalk ventrally for attachment to the surface of the tunnel. Thorax regularly domed. It is brown speckled with black, and is lighter dorsally. Length, 20 mm.

Note on probable food. The very powerful head and mouth-parts seem to suggest that the larva feeds on bark or more probably on the inner heart-wood of the twigs. It certainly bores tunnels into these, but will not feed up in captivity. Its actions, on the other hand, seem to point to a concentrated food, for it will remain motionless in the same place for several days without apparently feeling the need for food. Possibly an ant fungus is the food, in which case the powerful jaws would serve merely to enable the larva to bore into the nests in search of it. It remains in its own tunnels, although it can also be found just inside the entrances of those of the ants. In the immature stage it is found on the twigs, and will in captivity feed up for a short time on the leaves.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, March, 1933.

24. *Spindasis nyassae* (Butl.) (40).

Aphnaeus nyassae Butler, 1884, *Ent. mon. Mag.*, 20 : 251.—*Spindasis nyassae* Aurivillius, 1924, in Seitz *Macrolep. World*, 13 : 413.

Food-plant. The larva is found on the bark of *Acacia stenocarpa* Hochst., *Entada abyssinica* Stend., Mimosaceae. It is always ant-attended and dies immediately if all ants are removed.

Egg. Not known.

Larva. The larva is extraordinarily like those of some Lymantriids. The dorsum is red-brown mottled with black, with a very fine grey dorsal line, the brown colouring entering the margins of the first three segments in stripes. On the dorsum, also, are two rows of orange warts bearing short white spines. The sides are white with rows of minute black spots. Head, small and polished brown, carried rather far forwards when on the move. The first and the anal segments are armoured with dark brown chitinous plates; the former or collar being hood-like and protecting the head, the latter, at segment 11, somewhat enlarged laterally and carrying two long black external tubercles. From these are exserted whitish thread-like organs which are directed inwards and slightly forward of the vertical, and are rapidly oscillated; the actual organs are about 0.5 mm. long. In front of the tubercles and just beyond the chitinous plate is the gland. Length, 20 mm.

Pupa. The pupa is usually found under the bark, the last few abdominal segments being folded under and attached. Head-case blunt, shoulders of wing-cases prominently angled, the thorax domed, smooth and polished. The abdominal segments are somewhat flattened, the divisions being sharply defined. Length, 15 mm.

Notes on the possible food. In the young stages, this species is also found on the terminal shoots and will feed on them, if ants are provided, up to a certain stage, after which in captivity it dies. The later stages in nature are spent on the bark among ants. The mouth-parts are small and I am inclined to think fitted best for absorbing a secretion, and that although it is able in the early stages to feed on the shoots and even does so with some advantage, it is not the main source of food supply.

Parasites. Two species of *Anilastus* (Hymen., ICHNEUMONIDAE) were bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, January, 1933.

25. *Chloroselas pseudozeritis tytleri* Rly., f. *umbrosa* Talb. (38).

Chloroselas pseudozeritis tytleri f. *umbrosa* Talbot, 1935, *Ent. mon. Mag.*, 71: 207, pl. IV, f. 4, 5, 7, 8 (Kenya).

Food-plant. The larva is found in the early stages on the terminal shoots of *Acacia stenocarpa* Hochst., Mimosaceae, always, however, on the stems; later it travels down to the bark of the tree.

Egg. Not known.

Larva. The larva is light brown with a darker dorsal line and wavy black lines along the centre of the sides. It is flattened, with the dorsum evenly rounded, and the margins scalloped and bearing long hair. The collar is armoured with a polished black chitinous plate, as also is the anal extremity. Head very small. Tuberles are present on the edges of the supralanal plate, and are exserted on stimulation and vibrated rapidly from side to side; they are long and whitish. Strangely enough there appear to be two glands, for the ants attend to a darker oval area just above the anal plate, and also to a structure under the collar. After many hours of watching under a lens, I am convinced that this is so, for an ant having once found the collar does not leave it, and they never showed a preference for the anal gland. The larvae are always covered with ants, and, in fact, are never without them and, as one would expect, quickly die if the ants are removed. Length, 15 mm.

Pupa. The pupa is hidden in cracks or under the bark. It is black and polished. In shape narrow, with prominent head-case and shoulders, the thorax slightly ridged, while the abdominal segments are tapered evenly to the extremity. The latter is slightly stalked and folded beneath the pupa for attachment to the bark. Length, 10 mm.

Note on the probable food. When very young the larva is found on the small twigs among ants, although the twig need not necessarily be carrying any leaves. Usually the ants are attending a scale insect and the larva lies among these. A twig carrying scale, however, and not ants, does not satisfy it, and I therefore came to the conclusion that the food has something to do with the ants and not with the scale. Having a few larvae which had not fed for some days, I presented them with a fresh twig covered with scale which the ants had been attending, and the surface of the twig was very carefully examined from end to end with a slow waving motion of the head. Every now and then the head was dropped motionless on to the twig and left there for a few seconds, as if sucking something; the scale was left severely alone and not even in-

vestigated. When about half grown the larvae leave the twigs and are found in the ant-runs on the bark, where again I have seen them moving very slowly over the surface. Although many hours have been spent watching, I have never seen an ant feed them. The mouth-parts have not been examined here microscopically, but they seem to be very minute and to suggest some secretion as the food; it is possible that it feeds upon something left in the runs by the ants, perhaps the excreta.

Ant associated. *Crematogaster (Acrocoelia) gerstaeckeri* D.T. st. *sjoestedti* Mayr. var. *tricoloroides* Sants.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, April and November, 1932.

26. *Axiocerses amanga* Westw. (34).

Axiocerses amanga Westwood, 1881, in Oates' *Matabeleland*: 351.—*Aurivillius*, 1924, in Seitz *Macrolep. World*, 18 : 421, t. 70 b, c.

Food-plant. The larva spins together the edges of a leaf of *Ximenia americana* Linn., Oleaceae, and lives under cover, feeding at night and pupating also in the leaf in an exactly similar manner to the HESPERIIDAE.

Egg. White, about 0.5 mm. in diameter at base, and nearly hemispherical. There seems to be no pattern of any sort visible at least through an ordinary lens, the shell being smooth. The egg is laid on the undersides of the leaves.

Larva. Hairy and coloured greenish-brown irrorated with white, darker on either side of the dorsum. The laterals are fringed with short light-coloured hair, as are also the segment rings. Collar black or very dark brown, head and anal extremity bluntly rounded, both gland and tubercles are present. The tubercles have black external casings and are exserted from these for a very short distance only, and quickly retracted again. They are rather larger in diameter than usual and are white with a darker centre and rounded apices. Attended by ants.

Pupa. The pupa is black with smooth and polished casing and no markings. Head-case bluntly rounded, and from here the pupa tapers evenly to the posterior extremity.

Ant associated. *Camponotus (Myrmopyromis) niveosetosus* Mayr, var.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-700 feet, November, 1932, and March, 1933.

27. *Leptomyrina lara* (L.) (44).

Papilio lara Linnaeus, 1764, *Mus. Lud. Ulr.* : 320.—*Leptomyrina lara* Aurivillius, 1924, in Seitz *Macrolep. World*, 18 : 423, t. 70b.

Food-plant. The larva burrows into the thick fleshy cortex of the leaves of *Kalanchoe Lugardii* Bullock, Crassulaceae, hollowing them out until full grown, when it emerges to pupate.

Egg. Very small, white and evenly domed, being a complete hemisphere, less than 0.5 mm. diameter at base. It is laid singly on the upper or under surfaces of the leaves, usually low down on the plant.

Larva. The larva is pale translucent green, with a narrow pink dorsal line and wavy lateral lines, and in addition with a row of small black spiny warts along each side. Through a lens the skin is seen to be clothed with short yellowish hair. In shape the larva is somewhat flattened, the anal extremity broadly rounded and the lateral "skirts" well developed with scalloped margins. Head very small and dark brown. Length, 22 mm.

Pupa. Green or brown, speckled and peppered with grey. Seen from above

it is evenly curved from the head to the posterior extremity, the widest point being about the centre and the outline nearly oval. There are laterally neither "waist" nor "shoulders." The abdominal segments are much contracted and therefore wider than usual, and the head-case smoothly rounded, not bilobed. In profile the thorax is slightly domed, there being a small depression between it and the abdominal segments. It is broader and shorter in size than is common in this type of Lycaenid pupa. Length, 10 mm.; breadth, 5 mm.

Parasites. *Tetrastichus sculpturatus* Waterst. (Hymen., CHALCIDIDAE) was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, April, 1933.

28. *Spalgis lemolea* Druce (39).

Spalgis lemolea H. H. Druce, 1890, *Ann. Mag. nat. Hist.* (6) 5 : 26.—Aurivillius, 1924, in Seitz *Macrolep. World*, 18 : 433, t. 71b.

Early stages : Lamborn and Poulton, 1911, *Proc. ent. Soc. Lond.*, 1911 : civ-cv.—Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 475 (larval habits and Coccid food) (S. Nigeria).—Mellor, 1929, *Proc. ent. Soc. Lond.*, 4 : 8.

Food. The larva feeds on Coccids which in this case were living on an ornamental foliage plant.

The carnivorous nature of the larva was first described by the Rev. A. C. Good in West Africa (1892, *Psyche*, 6 : 201). Mr. J. E. M. Mellor found the larvae feeding on Coccids on a Cycad in Zanzibar.

Larva. Broad and slug-like, either black or dark grey, and hairy. The colouring, however, is usually invisible for it covers itself with a white waxy secretion produced by the Coccid and is then very hard to detect. Length, 15 mm.

Pupa. The pupa is an interesting example of protective coloration. It is placed most conspicuously on the upper surfaces of the leaves and coloured in whites, greys and blacks to represent a bird-dropping, which it does exactly. The anal extremity is tapered to a narrow square-ended stalk, which serves as an attachment to the leaf. From here, the abdominal segments are much broadened and intersegmentally contracted, being thus roughly spherical. There follows a slight waist between these and the thorax, which is slightly domed and falls vertically to the leaf. The head-case is placed beneath the pupa on the edge of the flattened ventral surface. From the wing-cases and including them, round the front of the thorax, the lateral margins are white, as also is the posterior half of the abdominal segments, while the remainder is blackish-brown mottled and irrorated with white or cream. Length, 7 mm.; breadth, 4 mm. at broadest point.

It seems that the protection afforded by its coloration is most effective, for out of 15-20 pupae taken from one small bush, not one was parasitised, and judging by the numbers on the bush, both of fresh pupae and empty cases, the birds had not discovered the deception.

Locality. Uganda : Bunyoro, Bugoma Forest, September, 1932.

29. *Anihene wilsoni* (Talb.) (6).

Lycaenesthes (Cupidesthes) wilsoni Talbot, 1935, *Ent. mon. Mag.*, 71 : 121, pl. II, f. 10, pl. III, f. 13 (Abyssinia), ♀.

Food-plant. The larva is found in ants' nests in hollow trees, in this case *Acacia abyssinica* Hochst., and *Entada abyssinica* Stend., both Mimosaceae. As a rule it is found right in the nest amongst the ant larvae and debris at the bottom, or in the early stages along the runs.

Egg. I have not seen the egg of this species.

Larva. The larva is in shape and colour like a wood-louse, being broad and flattened, with deeply incised segments and rounded dorsum, coloured grey. The skin is smooth and polished and the segments overlap, the first completely covering the head. Both extremities are broadly rounded and there are short lateral fringes of hair, and hair also on the segment rings. Neither tubercles nor gland appear to be present, a most surprising fact in view of its very close association with the ants. Length, 18 mm.; breadth, 6 mm.

Pupa. A hard, dark brown cocoon is built against the side of the ants' nest; it is formed from the wood-debris at the bottom of the nest. The pupa itself is black with domed thorax and bluntly prominent head-case. The abdominal segments are broad and flattened with lateral rows of hair-bearing warts running longitudinally down each side. The posterior extremity terminates abruptly in a broad, flattened stalk, which is attached to the tree from inside the puparium. Length, 15 mm.

Note on the probable food. The larva will not feed up in captivity on anything so far tried. The ant larvae and pupae were refused and if the ants feed it, the act has never been observed. When placed in a box with ants, it is usually devoured within a few hours. Bark, the debris from the nests or the ligneous material built round the insides of the nests, met with no better success, so that it seems probable that a fungus grown by the ants may be the food.

Locality. Kenya: Kitale, December, 1932; Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, January, 1933.

30. *Anthene ligures* (Hew.) (60).

Lycaenesthes ligures Hewitson, 1874, *Trans. ent. Soc. Lond.*, 1874: 349 (Angola).—Aurivillius, 1924, in *Seitz Macrolep. World*, 13: 440, t. 71f.

Food-plant. *Celtis* sp., *Urticaceae*.

Egg. The eggs are white and very flattened and laid on the under surfaces of the leaves. Diameter, 0.5 mm.

Larva. The larva is very broad and flat. Green with darker green dorsal line, flanked on either side with yellow. It carries short hair especially fringing the scalloped margins. Collar unusually large and broad. Dorsum rounded and spiracles white. There are apparently neither tubercles nor gland, and no ants were in attendance. Length, 15 mm.; breadth, 5 mm.

Pupa. The pupa differs from those of other *Anthene* in that the abdominal segments are centrally very broad and much flattened. It is placed horizontally on the underside of a leaf and attached with silk, both on the surface of the leaf and over the dorsum. In colour it is greenish-brown with fine dark dorsal line, and a white triangular spot between the thorax and abdominal segments, and with the same white spiracles as in the larva. The head-case is narrow, sloping sharply outwards to the broadest part midway along the abdominal segments and then abruptly back again to the extremity, the shape being, therefore, roughly that of a diamond. Length, 9 mm.; breadth, 6 mm.

Locality. Kenya: Kavirondo, Kabras-Kakamega.

31. *Anthene definita* (Btlr.) (8).

Lycaenesthes definita Butler, 1899, *Ann. Mag. nat. Hist.*, (7) 4: 342.—Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910: 26, pl. I, f. 5 (♀), f. 6 (♂).—Aurivillius, 1924, in *Seitz Macrolep. World*, 13: 441, t. 71e.

Food-plant. The larva is a very general feeder and may be found on the young shoots of many different plants of widely different families. They are given

here in their order of popularity, though the first is probably the original and undoubtedly the most important: *Bersama engleriana* Gurke, Melianthaceae; *Kalanchoe crenata* Haw., and *Kalanchoe Lugardii* Bullock, Crassulaceae; *Acacia abyssinica* Hochst. et Benth., *Acacia stenocarpa* Hochst., *Albizia gummiifera* (Gmel.) C. A. Smith, Mimosaceae; *Rhus incana* Mill., Anacardiaceae. As regards the second family and the last, the larvae feed on the flowers, otherwise on the young leaves.

Egg. The egg is circular, somewhat flattened, and very pale green when freshly laid. Diameter, about 0.5 mm.

Larva. The larva is a modification of the usual onisciform type. The dorsal ridge consists of single tent-like processes, each much enlarged and very sharply pointed with the posterior surfaces cut off vertically. The collar is very prominent, projecting far anteriorly and completely covering the head. Lateral edges strongly scalloped and fringed with hair. The colour varies with the food-plant, sometimes red (*Albizia*) or green (*Bersama*) or a combination of dark and light green, giving it a speckled appearance, very effective on the feathery inflorescence of *Rhus incana*. The inner edges of the dorsal processes and the edges of the carapace are usually white or pinkish-white. The anal segments are small with prominent anterior shoulders and the extremity narrowly rounded. The tubercles appear just between the last pair of spiracles and the shoulders mentioned above, and are therefore rather near the edge. They are long, thin, and white, with a large terminal rosette of spines, and are exserted vertically. The gland, with oval pinkish orifice, is placed centrally just above these. Length, 15 mm.

Pupa. Green or brown with a white diamond-shaped mark in the depression between thorax and abdominal segments. The shape, seen from above, is also that of a diamond, being rather pointed at the extremities and from each diverging in straight lines to the widest part in the centre, with a small irregularity at the shoulders of the thorax. In profile the thorax is ridged, followed by a depression, and lastly the abdominal segments are much contracted and curve strongly and abruptly to the extremity. It is fixed with silk flat on the surface of a leaf or stem. Length, 11 mm.; breadth, 6 mm.

Parasites. *Brachymeria* (probably *leighi* Cam.) (Hymen., CHALCIDIDAE) was bred, as well as a Tachinid.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, January and March, 1932.

32. *Anthene otacilia kikuyu* (B.-B.) (5).

Lycaenesthes otacilia kikuyu Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 37, pl. II, f. 2 (♂)
—Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 443.

Food-plant. The larva feeds on the young terminal shoots of *Acacia stenocarpa* Hochst., and *Acacia Lahai* Stend., Hochst., et Benth., Mimosaceae.

Egg. I have not seen the egg of this species.

Larva. The larva is very similar to that of *A. pitmani*. In colour very dark green, it is more than usually hairy, and in this latter respect quite different from the other. The dorsum is double ridged, bluntly but prominently toothed, the points of the teeth being yellow and the depressions between red. Collar small, though segments 2 and 3 are much enlarged and almost overhang it. The lateral skirts are scalloped and edged with yellow. The flattened anal segments are narrow and rounded posteriorly, light chalky green with a longitudinal dark green dividing line; somewhat more than half-way between this and the edge are the tubercles, yellowish-white, rather long delicate structures, with a terminal

rosette of bristles, and exserted somewhat laterally of the vertical. The gland is placed midway between, with a black crescent-shaped orifice. Length, 12 mm.

Pupa. Identical with that of *A. pitmani* Stempff., except that the head-case is much broader.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, April, 1933.

33. *Anthene pitmani* Stempff. (4).

Anthene pitmani Stempffer, 1936, *Rev. Fr. Ent.*, 3 : 139, f. 4 (genit.) (Kenya).

Food-plant. The larva feeds on the young shoots of *Acacia stenocarpa* Hochst., *Acacia abyssinica* Hochst. et Benth., and *Acacia Lahai* Stend., Hochst., et Benth., Mimosaceae.

Egg. The egg is circular, pale bluish-green, and flattened on top with a network of surface ornamentation in relief. There is a minute black central spot, less than 0.5 mm. in diameter. The egg is laid singly on the terminal shoots or leaflets.

Larva. Dark yellow-green with diagonal yellow lateral stripes and a yellow edging round the collar. The skin has a polished appearance as if moist. It is onisciform with well-developed collar and scalloped lateral "skirts." The dorsum is double ridged, the ridges consisting of rows of pointed tooth-like processes, the tips of which are yellow. The anal segments are flat and shield-shaped, and carry two tubercles placed rather close together. These are exserted vertically, and are very fine structures with a large terminal rosette. The gland is placed just under the last pair of "teeth" in the dorsal ridge, and is larger and placed further anteriorly of the tubercles than usual. Length, 12 mm.

Pupa. Either green or brown and sometimes with prominent silver lateral and dorsal stripes. It is placed with its long axis parallel to the leaf or bark, and attached by a silk thread centrally over the dorsum. The thorax is rather sharply ridged and outlined in silver. Head-case narrow. Length, 8 mm.

Ant associated. *Crematogaster (Acrocoelia) gerstaeckeri* D.T. st. *sjoestedti* Mayr.

Parasites. Three species of *Anilastus* (Hymen., ICHNEUMONIDAE) were bred, and also a Tachinid.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, July, 1933.

34. *Anthene lunulata* (Trim.) (3).

Lycaenesthes lunulata Trimen, 1894, *Proc. zool. Soc. Lond.*, 1894 : 51, pl. VI, f. 12.—Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 40, pl. II, f. 4 (♂), 5 (♀).—Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 444, t. 71c, f. g, h.

Early Stages: Farquharson, 1921, *Trans. ent. Soc. Lond.*, 1921 : 386 (larva on *Berlinia*) (S. Nigeria).

Food-plant. The plants eaten are *Entada abyssinica* Stend., Mimosaceae, and *Combretum* sp., probably *elgonense* Exell, Combretaceae. The larva feeds on the young shoots of the *Entada* and on the outer cortex of the young leaves of the *Combretum*.

Egg. White, circular, and not very much flattened on top. It has a slight central indentation and a surface network pattern. Diameter, 0.75 mm. It is laid singly among the leaflets of *Entada* and on the upper or under surfaces of the leaves of *Combretum*.

Larva. Beautiful yellow-green with a darker dorsal line which is some-

times reddish with a mottled appearance due to much yellow striation. The dorsum is rounded and broad, collar very heavy and overhanging, the lateral skirts well developed with yellow scalloped edges. The anal segments are not so flattened as usual, but both gland and tubercles are present. The former is plainly visible, the orifice being oval and red, and below it are the tubercles near the outside edges of the segment. They are long, rather thick, and yellowish, and carry a terminal rosette. They are exserted slowly almost vertically, though slightly outwards, and are retracted slowly. Length, 15 mm.

Pupa. The pupa is smooth-skinned, yellowish-white or green, with a dark dorsal line and no other markings. The shape is uncommon, being almost without prominences, evenly torpedo-shaped and very pointed at the anal extremity. The thorax is very slightly ridged, but there is no waist. It is placed horizontally along a twig or leaf. Length, 11 mm.

Ants associated. *Camponotus (Myrmoturba) acvapimensis* Mayr; *Technomyrmex detorquens* Walker; *Pheidole* sp.

Parasites. Four species of *Neotypus* (Hymen., ICHNEUMONIDAE), including *N. intermedius* Mocs., were bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, June, 1933.

35. *Anthene princeps ugandae* (B.-B.) (45).

Lycaenesthes ugandae Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 32 (Entebbe).—Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 444.

Food-plant. The larva feeds on the young shoots of *Entada abyssinica* Stend.

Egg. Very small, white, and slightly flattened above. It is laid among the young terminal shoots.

Larva. The larva is very similar to that of *Anthene definita*, having a single dorsal ridge formed of a row of tent-shaped processes, except on the first three segments where it is double. They are not, however, as large or sharply pointed as in the former species. At the point of each process and along the scalloped lateral edges are rosettes of spiny hair. Collar broad but rather long. In colour it is green, the lateral edges of the dorsal process being pink and those of the carapace pink and white. In addition there are rows of darker green diagonal stripes along the sides. Apparently without tubercles and gland. Length, 15-16 mm.

Pupa. The pupa is rather similar to that of *Anthene definita* and *A. larydas* in that it has a white spot stretching from the centre of the thorax to the mid-dorsal depression, but here the resemblance ends. In shape it is rather narrow and of almost equal width throughout, and so quite different from the roughly diamond-shaped pupae of the others. It is brown or green with a slight dusting of black, and with a fine black dorsal line. Head-case broad and blunt, with slight shoulders and ridged thorax. Length, 9 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, May, 1934.

36. *Anthene livida* (Trim.) (7).

Lycaenesthes livida Trimen, 1881, *Trans. ent. Soc. Lond.*, 1881 : 443.—Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 34.—Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 444, t. 72g.

Food-plant. The larva eats *Kalanchoe crenata* Haw.; and *Kalanchoe Lugardii* Bullock, Crassulaceae, feeding for preference on the flowers and seeds, but also, when these are not present, on the outer cortex of the leaves.

Egg. Small, circular and white, with a slight upper indentation and a prominent network pattern embossed on the shell. It is laid usually among the flower-heads of the plant and also, sometimes, in the nodes of the young leaves.

Larva. The larva is pale green, of a shade exactly matching the leaves of the plant. There is a central, single dorsal ridge of the same structure as that of *A. definita* (Btlr.), that is, consisting of separate tent-like processes, sharply pointed and triangular in profile, but slightly less pointed and slightly smaller than in that species. The collar is heavy and bluntly rounded, and the lateral edges of the carapace only very slightly scalloped. The anal segments are broad and regular in outline and carry both tubercles and gland. The former are short, thick and white, and seldom exserted; the latter, placed just below the last dorsal "tooth," has a dark oval orifice. Length, 18 mm.

Pupa. The pupa is either green or smoky-grey, according to whether it is placed on a living or dead leaf, with lateral abdominal rows of minute black spots, and a faint, dark dorsal line. The thorax is sharply ridged, and in the depression between this and the abdominal segments is a white diamond-shaped spot edged with black. Head-case very broad and blunt. Length, 10 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, March and December, 1933.

37. *Anthene levis grisea* (Talb.) (59).

Lycaenesthes levis grisea Talbot, 1935, *Ent. mon. Mag.*, 71: 208, pl. IV, f. 9, 14, 15 (♂, ♀) (Budongo Forest).

Food. The larva lives among *Crematogaster* ants in the inner runs and nests; it feeds therefore among them, probably on fungi grown by the ants.

Egg. Unknown.

Larva. The larva is grub-like, oval and rounded dorsally, the extremities being very similar to each other in shape. The skin is leathery and highly polished with many pit-like indentations. The collar carries a large, black, polished, chitinous plate. At the anal extremity is a large gland with brown, oval orifice, but I was unable to induce it to exsert tubercles. It is always ant-attended. Length, 10 mm.

Pupa. It is placed in the ant-runs under loose bark, with no exterior protection from the ants, evidently relying on the highly polished and hard pupa casing. Regularly shaped, without protuberances, the abdominal segments being slightly broader than the thorax. There are practically no shoulders, and the head-case is rounded and jet-black. General colour very dark brown to black. Length, 9 mm.

Locality. Budongo Forest, Uganda, August-September, 1934.

38. *Anthene amarah* (Guér.) (2).

Polyommatus amarah Guérin, 1847, in Lefeb. *Voy. Abyss.*, 6: 384, pl. II, f. 5, 6.—*Lycaenesthes amarah* Aurivillius, 1924, in *Scitz. Macrolep. World*, 18: 445, t. 72b.

Food-plant. The larva feeds on the young terminal shoots of *Acacia stenorcarpa* Hochst., and *Acacia abyssinica* Hochst. et Benth., Mimosaceae.

Egg. The eggs are laid singly on the young shoots. They are whitish, circular and flattened, with a small dark central spot. Diameter, 0.5 mm.

Larva. The larva is green and onisciform with the lateral edges scalloped and the dorsum double-ridged and bluntly serrated: The points of the dorsal ridge and the scalloped edges of the carapace are yellow, and along the sides are

dark green, white-edged, diagonal stripes. Dorsal line between the ridges dark green. Collar bilobed. The anal segments are flattened as usual and carry a gland in the centre anteriorly and tubercles below it. The latter are interesting and unusual. The lateral anterior angles of the shield are enlarged and swollen to form shoulders, and the tubercles are exserted at a very sharp angle outwards from these; moreover, the orifice of each is on the side and therefore protected from above; the organs are rather longer than usual, whitish, with a large terminal rosette. Length, 14 mm.

Pupa. Placed among the leaves or on the bark, and therefore either green or brown. If green, there are yellow diagonal lateral stripes, and a white dorso-thoracic line with rows of prominent black spots along the abdominal segments. If brown, it is powdered with black and the black abdominal spots are not so prominent. Thorax ridged with a depression between it and the abdominal segments. Posterior extremity bluntly pointed. Length, 10 mm.

Ants associated. *Crematogaster (Sphaerocrema) bequaerti* For. var. *saga* Sants.; *Acantholepis affinis* Sants.

Parasites. The Hymenoptera bred comprise two species of *Anilastus*, a *Charops* (Hymen., ICHNEUMONIDAE), and an *Apanteles* (Hymen., BRACONIDAE); a Tachinid was also bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, May, 1933.

39. *Anthene larydas* (Cr.) (10).

Papilio larydas Cramer, 1780, *Pap. Exot.*, 3 : 180, pl. 282, f. H.—*Lycaenesthes larydas* Aurivillius, 1924, in *Seitz Macrolep. World*, 18 : 449, t. 71h.

Early stages: Lamborn and Poulton, 1911, *Proc. ent. Soc. Lond.*, 1911 : civ.—Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 477 (S. Nigeria).

Food-plant. The larvae feed on the young terminal shoots of *Albizia gummosa* (Gmel.) C. A. Smith, Mimosaceae, and rests on the undersides of the leaflets.

Egg. Very pale green, circular and flattened above with fluted sides and a small dark central dot. Diameter, 0.5 mm. They are laid singly on the upper or under surface of the leaflets, always near the end of a shoot.

Larva. The larva is onisciform, coloured pale green with pink or reddish markings, exactly resembling the coloration of the food-plant. The dorsum is ridged, though only bluntly so, with the segment divisions clearly defined, and it has a red dorsal line. The sides are faintly striped with yellow and darker green, the edges of the carapace being pink and squarely scalloped. The anal segments are flattened and shield-shaped and carry tubercles, placed rather far anteriorly and near the outside edges of the shield. The tubercles are about 0.5 mm. long, whitish, with a large, spiny, terminal rosette, and are exserted laterally to the vertical. The gland is plainly visible as a small darkened patch with raised lips, placed about half-way between and just above the tubercles. Length, 15 mm.

Pupa. The pupa is dirty green with minute black speckling and a well-defined black dorsal line which encloses a white triangular spot at the junction of the thorax and abdominal segments. The latter are much contracted, being short and broad, and much pointed posteriorly. The thorax is ridged. The pupa is placed horizontally on the bark or stems of the tree. Length, 10 mm.

Ant associated. *Crematogaster (Sphaerocrema) striatula* Em. var. *horatii* Sants.

Parasites. *Neotyphus intermedius* Mocs. (Hymen., ICHNEUMONIDAE) was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, December, 1931—January, 1932.

40. *Anthene crawshayi* (Btlr.) (1).

Lycaenesthes crawshayi Butler, 1899, *Ann. Mag. nat. Hist.*, (7) 4 : 342.—Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 45, pl. II, f. 6.—Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 450, t. 71 h.

Early stages : Farquharson, 1921, *Trans. ent. Soc. Lond.*, 1921 386 (larva on *Cassia alata*) (*S. Nigeria*).

Food-plant. The larva feeds on the young terminal shoots of *Entada abyssinica* Stend. and occasionally on *Acacia abyssinica* Hochst., et Benth., Mimosaceae.

Egg. White or very pale green, circular and flattened above. It is heavily embossed with a minute network pattern, and is centrally depressed with a small black spot in the depression. Diameter, 0.5 mm. It is laid among the young shoots of the tree.

Larva. The larva is very similar to that of *A. larydas* (Crm.), being onisciform, green with a dark dorsal line, and with dark diagonal lateral stripes. The only differences are that the collar is not so massive, being, though well developed, much narrower, the anal segments are shorter and narrower, and the tubercles are therefore nearer to the extremity than in *A. larydas* (Crm.). In shape, size, and relative position, the tubercles and gland are almost identical with those of that species. The lateral edges of the carapace are white and squarely scalloped. On examination through a lens, with ants in attendance, the orifice of the gland can be distinctly seen to open, emit a drop of secretion, and then close again. Length, 15 mm.

Pupa. The pupa is placed among the leaves or in cracks of the bark. It is exactly similar in shape to that of *A. larydas* (Crm.), except that the thorax is slightly less ridged. The dorsal line is black, enclosing a white diamond-shaped spot as before, and the spiracles are white and rather conspicuous. Length, 10 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, February, 1932.

41. *Anthene nigeriae* (Auriv.) (9).

Lycaenesthes nigeriae Aurivillius, 1905, *Ark. Zool.*, 2 : 16, pl. III, f. 4; *ibid.*, 1924, in *Seitz Macrolep. World*, 13 : 452, t. 72b.—*Triclema nigeriae* Bethune-Baker, 1910, *Trans. ent. Soc. Lond.*, 1910 : 78.

Food-plant. The larvae feed on *Acacia stenocarpa* Hochst., and *Acacia abyssinica* Hochst., et Benth., Mimosaceae, into the thick fleshy stems of the terminal shoots of which they burrow. They are always attended by ants, which in this species are essential to life; if the ants are removed, the gland and tubercles grow mould and the larva dies.

Egg. I have not seen the egg of this species.

Larva. In the early stages the larva is a dirty brownish-white, changing later to green and brown, and when full grown to black with grey markings. The segments are grey with well defined black divisions, the sides and anal segments mostly black. In shape, broader than usual, with evenly rounded dorsum, flattened gradually towards the extremities. The carapace is very well developed, completely covering the legs and venter, but the collar is small and unusual. Here, as in the case of *Chloroselas pseudozeritis* (p. 218), there is a hard, shiny, chitinous plate for protection against ants, and, as in that species, ants are constantly in attendance at both extremities, the gland

of the collar being apparently under this anterior plate. The anal segments are somewhat flattened and protected by a circular plate of similar hard chitin, and they carry both tubercles and gland. The former are just below, on either side of the plate, in two small dark patches; they are short and dirty white, with a slight rosette. They are exserted vertically, but not vibrated. The gland, just above the plate, is shaped like a half-moon and is brown. Length, 13 mm.

Pupa. The pupa is dark sepia-brown with slight striation of lighter colour on the dorsum and a dark abdominal dorsal line. It is very evenly curved with little or no ridge on the thorax or "waist" between the latter and the abdominal segments. The head-case is narrower than usual and somewhat pointed, but not prominent. Length, 9 mm.

Ant associated. *Crematogaster (Sphaerocrema) bequaerti* For. var. *saga* Sants.

Locality. Mt. Elgon.

42. *Phlyaria cyara* (Hew.) (19).

Lycaena cyara Hewitson, 1876, *Exot. Butt.*, 5, *Lyc.*, pl. I, f. 9, 10 (Angola).—*Cupido cyara* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 460, t. 72h.

Phlyaria cyara f. *tenuimarginatus* Grünb., 1908, *SitzB. Ges. nat. Fr. Berl.*, 1908 : 475.—Aurivillius, 1924, *loc. cit.* 13 : 460 (*Cupido*).

Food-plant. The larva feeds on the young shoots of *Albizzia gummifera* (Gmel.) C. A. Smith, Mimosaceae.

Egg. Not known.

Larva. The general colour is light brown with a darker patch on segments 6 and 7 and on the points of the dorsal process, the anal segments bright green. Running round the collar and for some way back along the sides is a fine black line. In shape, it is unusual; sloping upwards sharply from the flattened anal segments there are first two massive tent-like processes on segments 8 and 9, thereafter a depressed area as far as the thoracic segments, and lastly here again the same large dorsal prominences, becoming gradually smaller towards the head. The collar and carapace are in this species very well developed. On the flattened anal segments near the lateral edges and about midway along them are two minute tubercles, white, and exserted vertically, being even then only just visible; placed centrally between them is a gland. Length, 15 mm.

Pupa. Brown or light brown, and smooth with a dark dorsal line throughout its length. The abdominal segments are long and broad, the thorax small, narrow and slightly ridged, while the head-case is bluntly rounded, but hardly projects beyond the thorax. There is a distinct waist both laterally and dorsally between the latter and the abdominal segments. Length, 12 mm.

Locality. Kenya : Kavirondo, Kakamega, March, 1934.

43. *Phlyaria heritsia* (Hew.) (18).

Lycaena heritsia Hewitson, 1876, *Exot. Butt.*, 5, *Lyc.*, pl. I, f. 11, 12 (Cameroons).—*Cupido heritsia* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 460, t. 72i.

Food-plant. The larva feeds on the young leaves of *Bridelia micrantha* Baill., Euphorbiaceae, and rests on the under surfaces.

Egg. White, circular, and very small. It is laid on the very young shoots and usually well hidden.

Larva. The larva is a beautiful shell pink with a thick green dorsal line flanked on either side by fine irregular yellow lines. It is hairy, and the margins are squarely scalloped. In shape, it is broad and very much flattened, thicker, however, along the midline of the dorsum; a cross-section would therefore be a much flattened triangle. The outline tapers from the centre to each extremity. Just before pupation the colour changes to orange red with a dark dorsal stripe. There appear to be neither tubercles nor gland. Length, 13 mm.; breadth, 4 mm.

Pupa. The pupa is long and narrow and reddish-brown with two black spots on the shoulders of the abdominal segments, and a thin black dorsal line. The thorax is small but ridged, leaving a slightly depressed area between it and the abdominal segments, both laterally and dorsally. Placed among dead leaves or on the bark. Length, 11 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, March, 1932, and July, 1933.

44. *Uranothauma nubifer* (Trim.) (28).

Lycaena nubifer Trimen, 1895, *Trans. ent. Soc. Lond.*, 1895 : 187, pl. 5, f. 4, 4a.—*Cupido nubifer* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 462, f. 72i.

Food-plant. The larva feeds on the young shoots of *Acacia abyssinica* Hochst. et Benth., Mimosaceae, preferring the secondary to the terminal buds, and resting by day along the stems.

Egg. White, circular, and flattened, with a dark, slightly depressed, central spot. The edges are boldly fluted. It is laid lower down the branches than other *Acacia*-feeding Lycaenids, on the old leaflets, stems or bark, or in the nodes of the secondaries or spines, and always singly. Diameter, 0.75 mm.

Larva. The larva is pale green in the early stages and when mature is light brown. The dorsum is double-ridged and broadly toothed, the space between the ridges being chocolate and broader anteriorly. Collar broad and rounded. Along the sides are darker diagonal stripes ending each in a small black spot, and the edges of the carapace are strongly scalloped and fringed with hair. An unusual character in this species is that the scalloped lateral edges continue throughout the length to the posterior extremity, the actual extremity forming the final lobe. The anal segments therefore, although flattened as usual, have a scalloped lateral outline, and the dorsal ridge also continues further into them than in most other species. There is no sign of tubercles or gland and ants do not appear to be in attendance. Length, 13 mm.

Pupa. The pupa is blackish to brown, narrow, broadening gradually across the abdominal segments. Thorax somewhat elevated with a depression between it and the abdomen. Head-case square. There is a dark dorsal line, and the surface is hairy. Length, 8-9 mm.

Parasites. The Hymenoptera bred comprised three species of *Anilastus* and a *Mesochorus* (Hymen., ICHNEUMONIDAE), three *Apanteles* (Hymen., BRACONIDAE), and *Tetrastichus sculpturatus* Waterst. (Hymen., CHALCIDIDAE).

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, December, 1933.

45. *Uranothauma delatorum* Heron (27).

Uranothauma delatorum Heron, 1909, *Trans. zool. Soc. Lond.*, 19 : 161.—*Cupido delatorum* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 462.

Food-plant. The larvae feed on the young shoots of *Albizzia gummifera* (Gmel.) C. A. Smith, Mimosaceae, but are far more retiring than the other

common species, i.e. *Anthonomus larydas* (Cr.), which also feeds on this tree. They are usually found among the dense new growth of a coppiced sapling in forests or river beds.

Egg. Not known.

Larva. The larva is green or pink with a dark dorsal line, and is thickly coated with short hair. It is broad and rather flattened, evenly rounded over the dorsum. The margins of the carapace are pink or white, squarely scalloped, but not very well developed. The collar also is not as large as usual. Neither tubercles nor gland appear to be present. Length, 14 mm.

Pupa. Light reddish-brown dorsally, becoming darker on the wing-cases and thorax. In shape, elongate, tapering to the posterior extremity, with the thorax long and narrow. There is a fine dark dorsal line, and a black spot on either side of the junction of the thorax and abdominal segments, where there is a slight constriction. Surface hairy. Length, 8-9 mm. Placed in cracks of bark or under it.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, June, 1933.

46. *Uranothauma falkensteinii* (Dew.) (29).

Plebeius falkensteinii Dewitz, 1879, *N. Acta Acad. nat. Cur.* 41 (2) : 204, t. 25, f. 5.—*Cupido falkensteinii* Aurivillius, 1924, in Seitz *Macrolep. World*, 13 : 462, t. 73a.

Food-plant. The larvae feed on the young shoots of *Acacia abyssinica* Hochst. et Benth., Mimosaceae.

Egg. Not known.

Larva. The larva is olive-green with short thick golden hair, a dark dorsal line, and rows of dark diagonal lateral stripes. Collar rather long and pointed anteriorly. The dorsum is double-ridged, but not prominently so, the segments well defined and the margins slightly scalloped. The anal segments are not much flattened and are evenly rounded posteriorly. Tubercles are present, placed rather further forwards than usual and near the extreme edges. They are thick and white, the extremities being bulbous, carried on a thin stalk, and quite different from any other that has been bred here so far. The gland is placed above these in the centre, the orifice being small and narrow. Length, 12 mm.

Pupa. Brown, lighter on abdominal segments and hairy, with a dark dorsal line and dark lateral abdominal marks. Head-case blunt, not bilobed, thorax ridged with a slight depression behind it. The pupa is narrow, rather small, and somewhat pointed posteriorly. Length, 8 mm.

Parasites. Three species of *Anilastus* (Hymen., ICHNEUMONIDAE) and also a Tachinid were bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, January, 1934.

47. *Cacyreus lingeus* (Cr.) (26).

Papilio lingeus Cramer, 1781, *Pap. Exot.*, 4 : 176, pl. 379, f. F, G.—*Cupido lingeus* Aurivillius, 1924, in Seitz *Macrolep. World*, 13 : 463, t. 73a.

Food-plant. The larva feeds on the flowers and seeds of *Coleus Forskohlii* (Willd.) Briq., *Coleus lactiflorus* Vatke., *Calamintha simensis* Benth., *Calamintha elgonensis* Bullock, Labiate, and many other Labiates.

Egg. The egg is very small, greenish-white, and much flattened, with a large part of the central area depressed and darkened. It is laid on the immature flower-spikes, on the calices or among the flowers. Diameter, 0.25-0.5 mm.

Larva. The larva may be of almost any imaginable colour, green, purple,

maroon, brown, etc., according to the particular Labiate on which it is feeding, and is in fact one of the most wonderful examples of procrustis among the LYCAENIDAE. To give only one case: On *Colus lactiflorus*, it is bright green with the scalloped edges of the sides, the "teeth" of the dorsal ridge, and the anal segments rich bluish-purple, while the extreme points of the dorsal "teeth" are white. This merges completely with the coloration of the flower-spikes. The dorsal ridge is double, the dividing "valley" being broader anteriorly, collar small, and the whole very hairy. There is no sign of tubercles or gland. Length, 15 mm.

Pupa. The pupa is light brownish with minute black speckling and two black dorso-lateral stripes. It is narrow and of nearly equal width throughout. Head-case very broad and blunt, and thorax slightly ridged. The pupa is very hairy and the hair both in the larval and pupal stages seems to be a further advance in procrustis, for the food-plants are also mostly hairy. Length, 9 mm.

Parasites. The Hymenoptera bred were three species of *Anilastus* (ICHNEUMONIDAE), and a species of *Tetrastichus* (CHALCIDIDAE).

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, August, 1929, and March, 1930.

48. *Castalius hintza* (Trim.) (21).

Lycaena hintza Trimen, 1864, *Trans. ent. Soc. Lond.*, (3) 2: 177 (S. Afr.).—*Cupido hintza* Aurivillius, 1924, in Seitz *Macrolep. World*, 13: 466, t. 73b.

Food-plant. The larva feeds on the uppersides of the leaves of *Zizyphus jujuba* Lam., Rhamnaceae, attacking the outer cortex; it is coloured suitably for this mode of life.

Egg. The egg is white, circular, very much flattened, with a minute black central spot. Diameter, 0.5 mm. It is laid preferably on the undersides of the young leaves.

Larva. In colour, bright yellow-green, with fine yellow striation and a very fine double dorsal line reaching the anal extremity, but not quite to the head. The dorsum is evenly rounded, centrally broad, and tapering slightly to the extremities without any irregularities. It is somewhat similar to that of *Anthene lunulata* (Trim.) but broader. The anal segments are not perceptibly flattened, but carry both tubercles and gland. The former are short, fine, whitish structures placed half-way between the central dorsal line and the edges, and are exerted laterally at an acute angle to the vertical, disclosing small spiny rosettes at their extremities. The gland appears as a dirty whitish transverse line, and is placed centrally above the tubercles. Length, 16 mm.; breadth, 6 mm.

Pupa. The pupa is, unlike the larva, quite different to that from *A. lunulata* (Trim.), being of the normal blunt-ended type. It is dark brown, mottled heavily with black. The thorax is ridged, with a small depression between it and the abdominal segments both laterally and dorsally. It is slightly hairy, the hair, however, being visible only through a lens. Length, 10 mm.

Ants associated. *Crematogaster* (*Orthocrema*) *jeanneli* Sants.; a var. of the preceding; *Technomyrmex detorquens* Walker.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, July and September, 1933.

49. *Castalius cretous* Btlr. (20).

Castalius cretous Butler, 1876, *Ann. Mag. nat. Hist.* (4) 18: 485 (Abyssinia).—*Cupido cretous* Aurivillius, 1924, in Seitz *Macrolep. World*, 13: 467.

Food-plant. The larva feeds on the undersides of the leaves of *Zizyphus jujuba* Lam., Rhamnaceae, eating only the outer cortex and never through the

leaf. It is extremely hard to detect since the colour is exactly the same as that of the leaf, and it is always flattened against the surface.

Egg. The egg is very minute, circular, and much flattened, with no central indentation. It is pale yellow, and is laid singly on the under surfaces of the leaves.

Larva. The larva is broad and flattened, so much so that a cross-section would show much the same thickness from side to side. The extremities are rounded and very similar; the margins are scalloped and fringed with long pale-yellowish hair. Colour pale green with a narrow white dorsal line slightly raised above the general level. The tubercles are placed half-way between the edges and this central line. They are short thick structures without a rosette, and are exserted vertically. The gland, between and just above them, appears as a darker line across the dorsal ridge. Length, 15 mm.; width, 5 mm.

Pupa. The pupa is placed on the undersides of the leaves. It is dirty pinkish-brown with a few dark spots and streaks, and is slightly hairy. It is narrow, with thorax ridged, and with the usual waist between this and the abdominal segments. Length, 10 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, July, 1933.

50. *Azarus natalensis* (Trim.) (17).

Lycaena natalensis Trimen, 1906 : 79, pl. 6, f. 18, 18a (♂, ♀).—*Cupido natalensis* Aurivillius 1924 in Seitz *Macrolep. World*, 13 : 469, t. 73c.

Food-plant. The larva feeds on the young shoots of *Acacia abyssinica* Hochst. et Benth., Mimosaceae.

Egg. The egg is white, circular, and very flattened. Diameter, 0.75 mm. It is laid among the young shoots of the plant.

Larva. The larva is onisciform, and the ground-colour is very pale green. It has a modified double-ridged dorsum, the "teeth" of which are much flattened, leaving a dark green dorsal line between the ridges. Along the laterals are black, white-edged, diagonal stripes continuing in front round the collar. The latter is characteristic, being squarely pointed in front, the second segment also being somewhat swollen and hood-like. It is edged with white. The lateral "skirts" are pale yellow, heavy, and much broadened. The flattened anal segments are divided centrally by a broad dark green line, and half-way to the edge on either side are the tubercles, almost invisible in the light ground-colour and very minute. They are not apparently exsertile. Above them is a large gland. Length, 16 mm.

Pupa. The pupa is narrow and of nearly even width throughout, but tapering slightly to the rather pointed posterior extremity and to the head-case. The latter is square ended and prominent, and behind it are conspicuous "shoulders." The thorax is ridged and dorsally there is a depression between it and the abdominal segments. The surface is smooth and polished, coloured green or brown, with a dark dorso-abdominal line and rows of large black spots on the sides. In addition, there are a few black spots on the sides of the thorax. Length, 10-11 mm.

Ants associated. *Cataulacus donisthorpei* Sants.; *Engramma ilgi* For.

Parasites. The Hymenopteron *Tetrastichus sculpturatus* Waterst. (CHALCIDIDAE) as well as a Tachinid was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, April, 1933.

51. *Azarus jesous* (Guér.) (16).

Polyommatus jesous Guérin, 1847, in Lefob. Voy. Abyss., 6 : 383, pl. 11, f. 3, 4.—*Cupido jesous* Aurivillius, 1924, in Seitz *Macrolep. World*, 13 : 469, t. 73d.

Food-plant. The larva feeds on the young shoots of *Acacia stenocarpa* Hochst., and *Acacia abyssinica* Hochst. et Benth., Mimosaceae.

Egg. The egg is very minute, circular, white, much flattened above. Diameter, 0.25 mm. Laid among the terminal leaflets.

Larva. A beautiful bright green of a shade exactly resembling the food-plant. The dorsum is double-ridged and bluntly "saw-toothed," there being a depressed reddish-orange dorsal line between the ridges. The collar is narrow, hairy posteriorly, and edged with black. Along the margins are fine black diagonal stripes, and the edges of the carapace are scalloped. The last pair of teeth of the dorsal ridge are much darker in colour, the last two lateral stripes being jet black, so that the whole forms a dark patch just above the anal segments. These latter are flattened and carry a gland situated at the anterior extremity of a broad dark green longitudinal stripe, with the two tubercles placed close together on either side and just below the gland. These are exserted vertically, but not vibrated, and are longish, and white with spiny terminal rosette. Length, 12 mm.

Pupa. The pupa is very small, brown or green, the abdominal segments being lighter in colour, and having two rows of black dorsal spots. It is narrow and elongate, with thorax ridged, and a distinct depression between this and the abdominal segments. Head-case prominent, protruding rather far anteriorly. The pupa is placed on a stem of the food-plant, or in a crack of the bark. Length, 8 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, July, 1933.

52. *Syntarucus telicanus plinius* (Fabr.) (25).

Papilio plinius Fabricius, 1793, *Ent. Syst.*, 3 (1) : 284.—*Cupido telicanus plinius* Aurivillius, 1924, in Seitz *Macrolep. World*, 13 : 470; *ibid.*, loc. cit. 9 : t. 153b.

Food-plant. The larva feeds on *Indigofera arrecta* Hochst. et C. Rich.; *Indigofera subargentea* De Willd., Papilionaceae: lucerne and, no doubt, on many other leguminous plants. It is found among the flowers and seeds or on the young terminal shoots.

Egg. The egg is white, circular, and flattened, with a deep central depression. Diameter, about 0.5 mm. It is laid on the underside of the leaflets or in the nodes of the secondary shoots.

Larva. The larva is dark sepia-brown with lighter brown lateral striation; the skin is velvety. Along the dorsum is a broad, bluntly toothed double ridge, the segments being deeply incised and the space between the ridges broadening anteriorly. The latter is of the dark sepia ground-colour, while the points of the ridge are lighter. The collar is rather narrow, but moderately large, rounded in front with the margins slightly scalloped. The anal segments are almost triangular, with the tubercles carried about half-way along them and placed much closer to each other than is usual, being midway between the centre and the edges. They are comparatively very long, yellowish-white structures, and carry the largest terminal rosettes of any Lycaenid I have yet seen, consisting of spines of varying length, arranged perfectly symmetrically. The gland orifice appears as a small dark patch immediately above the tubercles. Length, 15 mm.

Pupa. The pupa is dull brown speckled with black, with a black dorsal

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line and prominent black spots on either side in the depression between the thorax and abdominal segments. It is entirely normal in shape, narrow across the head-case, with slight thoracic shoulders, and from these gradually broadens to the centre of the abdominal segments. Length, 10 mm.

Parasites. The Hymenopteron *Tetrastichus sculpturatus* Waterst. (CHALCIDIDAE) was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, March, 1930; Kavirondo, Kakamega, June, 1931.

53. *Cosmolyce baeticus* (L.) (24). .

Papilio baeticus Linnaeus, 1767, *Syst. Nat.* (ed. 12) : 789.—*Cupido baeticus* Aurivillius, 1924, in *Seitz Macrolep. World*, 13 : 471.—Seitz, in *Seitz loc. cit.* 1 : 290, t. 77h.

Food-plant. The larva feeds on *Crotalaria cleomifolia* Welw. et Baker, *Crotalaria cephalotes* Stend., *Crotalaria glauca* Willd., Papilionaceae; *Sutherlandia frutescens*; garden peas and many other leguminous plants are also attacked. The larva is found on the flowers and seed pods of all the above.

Egg. Circular, greyish-white, and about 0.5 mm. in diameter. The top is flattened, and there is a minute dark central spot, but no other ornamentation is visible through an ordinary hand lens. It is laid singly among the flowers.

Larva. In the early stages the larva is dirty greyish-green ornamented with a dark grey dorsal line and a series of dark grey wavy diagonal stripes along the sides. Later it becomes lighter in colour, until in the final stage it is entirely light dull green with only a hint of the original markings. It is slightly hairy. In shape, typical of many allied species, with evenly rounded dorsum and distinct segments and no prominences of any kind. Like its allies, also, it has a habit of humping itself dorsally when disturbed, in the manner of a wood-louse about to curl up. Both tubercles and gland are present; the former, placed rather near the anal extremity and towards the margins, are very minute whitish structures. They are exserted vertically and are very short, with small terminal rosettes. The gland has a large narrow oval surface, centrally above the tubercles and visible to the naked eye. No ants were in attendance, but this is probably a coincidence, since they are common on this group of plants. Length, 18-20 mm.

Pupa. The pupa is placed horizontally along a leaf, among debris at the foot of the plant, or sometimes in a seed pod. It is light brown with a few black spots and streaks, the abdominal segments being lighter and having double rows of dorsal spots and a fine dorsal line. The abdominal segments are broad and bluntly rounded at the extremity, the thorax ridged dorsally and the head-case prominent; between the abdominal segments and the thorax is a slightly depressed area. Length, 11-12 mm.

Parasites. The Hymenopteron *Neotypus intermedius* Mocs. (ICHNEUMONIDAE) as well as a Tachinid was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, June and December, 1933.

54. *Cyclirius crawshayanus* (Auriv.) (23).

Cupido crawshayanus Aurivillius, 1925, in *Seitz Macrolep. World*, 13 : 473 (nom. nov.).—*Scolitantides crawshayi* Butler, 1899, *Proc. zool. Soc. Lond.*, 1899 : 422, pl. xxv, f. 2, 2a (Machakos, E. Afr.).

Food-plant. The larvae feed on the fleshy outer cortex of the main tap root of *Cynoglossum coeruleum* Hochst. et D.C., Boraginaceae, always below ground; they are attended by many species of ants.

Egg. The egg is laid on the stem or lower leaves, usually singly. It is white, circular, and very flattened, with a slight depression inside the rim, and a small, raised, black spot in the centre.

Larva. The larva is dirty yellowish-white and semi-translucent, as one would expect from a life in total darkness. The skin is waxy, the segments sharply incised and the collar slightly darker in colour. It is broad but with no marked dorsal ridge. The anal segments are shield-shaped, broad and heavy, and carry anteriorly a gland with large oval orifice, and below it on either side and rather close to one another and to the central line are two tubercles. These do not appear to be exsertile; they are visible to the naked eye as two small oval areas with dark edges which, when ants are present, are vibrated just inside the orifice, the movement appearing through a lens like the very rapid opening and closing of the shutters of a camera. Length, 15 mm.; width, 4 mm.

Pupa. Translucent yellowish-white, with a dark dorsal line. It is long and narrow, the abdominal segments being especially long. The head-case is prominent, the thorax short and sharply ridged, with a depression between it and the abdominal segments. The latter are flattened, broad and rounded posteriorly. Shoulders prominent, wing-cases transparent. It is placed among the roots of the food-plant. Length, 12 mm.

Ant associated. *Monomorium (Monomorium) minutum* Mayr, var. *pallipes* For.

Locality. Mt. Elgon.

55. *Euchrysops malathana* (Boisd.) (32).

Lycaena malathana Boisduval, 1833, *Faun. Madag.* : 25.—*Cupido malathana* Aurivillius, 1925, in *Seitz Macrolep. World*, 13 : 484, t. 73f.

Early stages : Farquharson, 1921, *Trans. ent. Soc. Lond.*, 1921 : 378–380 (larva and pupa, on *Canavalia*) (S. Nigeria).—Lamborn, 1913, *Trans. ent. Soc. Lond.*, 1913 : 488 (larva and larval habits).

Food-plant. The larva feeds in the flowers of *Vigna monophylla* Taub., a species of ground-pea, and is therefore as a rule completely hidden. Just below the flower-buds there are several large plant glands and these are very attractive to ants of many species; it is not surprising therefore that this species, as described below, possesses both tubercles and gland.

Egg. The egg is very minute, only about 0.25 mm. in diameter. It is pale green, circular, and very much flattened, the lateral edges being prettily fluted, while above it is smooth with a minute black central spot. It is laid separately or in two's and three's in the nodes of the flower-stalks, and fixed in position with a polished, translucent gum, coloured like mother-of-pearl. It is commoner to find 2 or 3 than a single egg in one place, and they are laid quite haphazard, the second often overlapping the first and sometimes almost covering it.

Larva. Dull green or brownish-green with a series of blurred brown diagonal stripes along the sides, and a narrow brownish dorsal line. The dorsum is broadly rounded and the carapace well developed with scalloped edges. The collar is small but adequate to cover the head, proximally rounded. At the posterior extremity, there is a much flattened oval area, darkened centrally, carrying tubercles at its outermost edge, and a gland, with semicircular orifice, centrally above them. The tubercles are rather long whitish structures with a terminal rosette; they are exserted vertically. Length 12 mm.

Pupa. The pupa is transparent yellowish-brown on the thorax and wing-cases, and opaque on the abdominal segments. Along the latter is a dark dorsal

line and double rows of minute black lateral spots. In shape, it is narrow, tapering to the posterior extremity, with the thorax ridged and a distinct "valley" between it and the abdominal segments. Head-case narrow, but protruding rather far in front. Length, 9 mm.

Parasites. The Hymenopteron *Itoplectis suada* Tosq. (ICHNEUMONIDAE) was bred.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, May, 1934.

56. *Euchrysops osiris* (Hpffr.) (31).

Lycaena osiris Hopffer, 1855, *Mon. Bl. Akad. Wiss. Berl.*, 1855 : 642 (Mozambique).—*Cupido osiris* Aurivillius, 1925, in Seitz *Macrolep. World*, 13 : 484, t. 73h.

Food-plant. The larva eats the same small ground-pea as *E. malathana* (Boisd.), feeding on the flowers. This is rather an interesting species in that the larva and the imago are very similar to *E. malathana* (Boisd.) and the food-plant is the same. It is a much rarer species here and therefore it seems possible that it is associated with *E. malathana* (Boisd.) in Müllerian mimicry for purposes of protection.

Egg. The egg is the only stage in which there is much difference from the allied species. It is circular, greenish-white and flattened, with a very minute dark central spot. It is laid among the flowers, always singly, without the translucent gum of the other species, and is much larger, being 0.75 mm. in diameter.

Larva. Differs from that of *E. malathana* (Boisd.) in that it is slightly hairy and the skin roughened with whitish papillae. It is green, with blurred diagonal lateral stripes, and a red-purple dorsal line broadening anteriorly until segment 1, with the collar entirely of this colour. The dorsum is slightly ridged and corrugate, the segment divisions being deeply incised. The anal segments are flattened and rounded posteriorly, and carry both gland and tubercles, the area round them being slightly darker than the remainder. The gland is black and oval followed by a short black line; the tubercles are placed just at the extremities of this on either side, and about half-way to the edges of the carapace. They are very small, thin whitish structures with terminal rosettes consisting of a few hairs only, and are exserted vertically. Length, 15 mm.; breadth, 4 mm.

Pupa. Greyish-brown to dark brown. It has a narrow black dorsal line and sometimes also rows of black lateral spots. The abdominal segments are rather broad and bluntly pointed posteriorly. Thorax slightly ridged with the usual small dorsal depression. Head-case not prominent. Length, 12 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, August, 1931.

57. *Eicochrysops nandianus* (B.-B.) (22).

Chilades nandiana Bethune-Baker, 1906, *Ann. Mag. nat. Hist.* (7) 17 : 109.—*Cupido nandianus* Aurivillius, 1925, in Seitz *Macrolep. World*, 13 : 488.

Food-plant. The larva feeds among the seed-pods or on the leaves of a small weed which grows in grass-land.

Egg. Very pale green, circular and very flattened, with a small dark central spot. Diameter, about 0.25 mm. Laid on leaves and seed-pods, usually rather near the ground and somewhat indiscriminately. Every specimen of the plant will be found to carry 10-20 eggs. When ovipositing the female always rests with open wings, thus prominently displaying the bright red marginal

spots of the hind-wing. Since the plant grows on the ground only 7-8 in. high, lizards are probably the chief enemies, and the red aposematic marks are therefore no doubt for their benefit. This is an unusual position for oviposition, most other species preferring to lay with closed wings, relying on the procryptic underside for protection.

Larva. The larva is narrow and green with a broad dark dorsal line and white margins, the whole thickly covered with short hair. Anal extremity broadly rounded and collar well developed. The dorsum is curved but there is no ridge or other irregularity. Length, 9 mm.

Pupa. The pupa is placed horizontally along the stem of the plant. It is narrow and pale green, the abdominal segments being lighter, and with the head-case and thorax covered with rather long whitish hair. The wing-cases are smooth, rather longer than usual, reaching midway along the abdominal segments and ornamented posteriorly with a few black spots. There is a dark dorsal line and a row of black dorsal spots, and along the sides of the thorax three jet-black diagonal stripes, while in continuation from these along the sides are minute black dots, one to each segment. There is no waist between the thoracic and abdominal segments. Length, 7 mm.

Parasites. The Hymenopteron *Tetrastichus sculpturatus* Waterst. (CHALCIDIDAE) was bred.

Locality. Kenya: Trans Nzoia, August, 1933.

58. *Cupidopsis cissus* (Godt.) (30).

Polyommatus cissus Godart, 1823, Enc. Méth., 9 : 683.—*Cupido cissus* Aurivillius, 1925, in Seitz Mucrolep. World, 13 : 489, t. 74g.

Food-plant. *Erioscma cordifolium* Hochst., a species of ground-pea. The larva feeds in the seed-pods, boring into them and feeding on the immature seed.

Egg. The egg is larger than usual, white and completely flattened above. It is laid in the nodes among the immature flower spikes. Diameter, 0.75 mm.

Larva. The larva is green with triple dorsal lines, the central one being red-brown and the outer ones yellowish-green. It is thickly clothed with short whitish hair, and along the sides, above the edges of the carapace, are rows of small black spots. Very regular in shape with no prominences, the dorsum rounded and the reddish edges of the carapace slightly scalloped. Seen from above it is torpedo-shaped, posteriorly very pointed and much broader than usual in comparison with its length. There appear to be neither tubercles nor gland, nor have I seen ants on the food-plant. Length, 12 mm.; breadth, 5 mm.

Pupa. The pupa is green with a fine black dorsal line and fine white lines flanking it on either side. It is covered with white spiny hair. In shape, narrow, with sharply pointed posterior extremity, thorax slightly ridged and head-case blunt-ended. The wing-cases and central parts are smooth, polished, and immaculate. Length, 10 mm.

Locality. Mt. Elgon, 18 miles S.W. of Kitale, 6-7000 feet, November and December, 1929.

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DIMORPHISM IN THE MALES OF STAG-BEETLES (COLEOPTERA,
LUCANIDAE)

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(*British Museum (Natural History)*.)

[Read 5th May, 1937.]

WITH PLATES 1 TO 3.

IN 1928, *Trans. ent. Soc. Lond.*, **76**, I published a paper on Polymorphism in Horned beetles, containing an account of various Dynastine and Coprine Coleoptera in which males of the same species exhibit markedly different phases in the horns borne on head and thorax. These different phases are in most cases linked together by individuals showing transitional stages, but in some cases no intermediates have been found, although large numbers of specimens have been examined.

A typical case of the latter kind is a large and abundant South American Dynastine beetle, *Enema pan* F. The male of this insect has a forked horn upon the thorax and a simple horn upon the head. I gave reasons for believing that another male form known as *E. infundibulum*, in which the conditions are reversed, the thoracic horn being simple and that of the head forked, is a phase of the same species, although no intermediate stages are found. The first-mentioned phase occurs in various degrees of development, the second is found in large specimens only and is almost constant.

At the time of writing my former paper I had made no study of the Stag-beetles (LUCANIDAE), but, having since devoted some time to studying the group, I have found that the mandibles of the male in many species exhibit the same curious phenomenon as I described in the horns of the other groups.

Although males and females of DYNASTINAE and COPRINAE are frequently very dissimilar, there is no other group known to me in which such extreme dissimilarity occurs as in the LUCANIDAE, insects with larviform females only excepted. In the common Stag-beetle of southern England, *Lucanus cervus*, there is scarcely any external feature common to the two sexes. Shape, colour, surface-sculpture, form of the legs, antennae, jaws and other organs of the mouth, all are different. But in many other species the differences are much more striking. The male may in addition be uniformly coloured, while the female has conspicuous stripes, as in *Dorcus wimberleyi* and *Homoderus mellyi*, or, as in *Calcodes gazella*, male and female may have different patterns. In others the male is dull sooty black or brown, and the female glossy, as in *Dorcus saiga*, and in others again the male is smooth and the female deeply grooved along the back, as in *Dorcus curvipes* and *reichei*.

The correct association of the two sexes in this family is therefore a matter of exceptional difficulty. Unless many specimens are found in the same locality, evidence of specific identity may be entirely absent, and there are species which have been known for very many years of which the two sexes remain still unassociated.

Females as a rule show little variation except in size, but males are extremely variable, and two males of the same species may differ from one another as greatly as two specimens of opposite sex.

In discussing Polymorphism in Horned beetles, I drew attention to the fact that, in species with hornless females, the horns tend to disappear in dwarfed males, but that this is not the case when the female also is horned. In the same way, dwarfed male LUCANIDAE assume to a greater or less extent the characteristics of the female and may differ extremely from well-developed males. In *Dorcus saiga*, in which the female is glossy black, well-developed males are dull and sooty, but small examples are glossy like the female. Similarly, in *Dorcus tityus*, in which the female has deeply grooved elytra, dwarfed males are similarly grooved, but a series of specimens of gradually increasing size shows the gradual smoothing of the elytra until all trace of the grooves disappears. Until such series were brought together, isolated specimens were of necessity regarded as representing different species.

Although the changes which accompany increase of size affect almost every part of the body, they are generally most apparent in the mandibles. In many species the course of development of these is as follows. In the smallest males they are close together, with the inner edges in contact, straight, and finely and closely but irregularly toothed, a form evidently suited for gripping and probably primitive. This form is almost always lost in well-developed specimens. With increasing size the head becomes broader, the mandibles separated at the base, attenuated, bent or curved, at last meeting only at the tips, the teeth become fewer and larger, and fantastic shapes may be produced which by no means suggest fitness for any practical use.

Various recent authors have called attention to the correspondence between the degree of development of the mandibles and the size of the insect, and have shown that the former is mathematically determined by the latter. The rule, however, is subject to remarkable exceptions. In his Monograph * of the group of Stag-beetles which he called the Odontolabini Leuthner used various names, Priodont, Mesodont, Amphiodont and Telodont, to describe the mandibles in different stages of development, the primitive, finely toothed stage being called Priodont and the ultimate, most highly developed, condition Telodont. The comparatively small number of specimens available to him was insufficient to show that, whilst in all the lower stages every transition existed, the last (Telodont) stage in many cases formed a quite distinct and isolated phase. It is unfortunate that Dudich, in discussing the variation of the mandibles of a Lucanid (1923, *Arch. Naturg.*, **89** (A) 2 : 69), has used the term Telodont for an intermediate stage and introduced another, Mesamphiodont, for the extreme form.

When fairly large numbers of male LUCANIDAE of the same species are available, it will be found, by arranging them according to size, that in certain species, e.g. *Dorcus suturalis* Oliv. (pl. 3, figs. 1-2), the progressive development of the mandibles shows a rather remarkable interruption. At a certain point increase of bodily size ceases but that of the mandibles does not. Specimens are found, very rare in some cases but frequent in others (figs. 1a, 2c), in which the mandibles have attained considerably greater development unaccompanied by any further increase of bodily size. Such specimens are practically constant in form and not linked by intermediates with the progressive series into which the others range themselves. Leuthner, in the monograph just referred to, has figured side by side, as in *Calcodes (Odontolabis) burmeisteri* and *aeratus*, male specimens of identical size with entirely different mandibles. M. Paulian also has recently mentioned (1936, *Proc. zool. Soc. Lond.*, **1936** :

* 1885, *Proc. zool. Soc. Lond.*, **1885** : 385.

756) two species of *Odontolabis* in which there are two separate forms of male. Neither author, however, has dealt further with this curious fact.

Calcodes carinatus L. (pl. 1, fig. 4) is an abundant representative of its genus in Ceylon. In small examples (fig. 4a) the short mandibles, when closed, are in close contact and their inner edges are finely and irregularly toothed. In larger specimens (fig. 1b) the teeth are larger and farther apart, and in very well grown specimens a broad basal lobe and a long pointed tooth at some distance from it become isolated from the rest, leaving a considerable gap before and after the long tooth (fig. 4c). A series of about fifty males which I have examined show a gradual progression to this stage, at which the maximum size is reached. But thirteen specimens, all of large, but not larger size, (fig. 4d), have much longer and more slender jaws, which are entirely smooth to beyond the middle. The basal lobe and the long tooth have disappeared, but another slightly forked tooth has made its appearance towards the end. These thirteen specimens are all alike, and no connecting link between them and the ordinary progressive series can be found.

An exactly similar condition exists in various other species of the same genus. A common Himalayan species, *Calcodes cuvera*, may be mentioned as an example. Small males have mandibles similar to those of *Calcodes carinatus* but, with increasing size, the close irregular teeth become fewer and larger, and in large examples, in which the length of the jaws is almost equal to that of the head, a single long tooth appears detached from the rest near the base, the remaining teeth being irregular and unsymmetrical. This condition marks the end of the progressive stage in more than fifty males which I have examined, but there are other specimens in which the mandibles are much longer than the head, slender, symmetrical and without the long tooth before the middle, instead of which there is a forked branch beyond the middle and a sharp angle at the base. This form also is practically constant and is not connected with the inconstant form by any intermediate specimens. The two phases occur together in the same localities. The two phases of another very abundant Indian Stag-beetle, *Calcodes siva*, are shown in plate 1, fig. 2.

A Bornean member of the same genus, *Calcodes brookeanus* (pl. 1, fig. 3), shows the phenomenon still more strikingly. Small specimens have very broad flat jaws of nearly semicircular shape, their inner edges serrated and meeting. Except in size, this form shows little change until very large specimens are examined. These may have the teeth absent at the base (fig. 3a), leaving a small gap there, or they may have entirely different mandibles which, instead of being broad, are very slender, meeting only at the tips, which are acute, and with a long sharp tooth projecting inwards near the middle of each (fig. 3b). Here again a long series of specimens shows no connecting links.

A still more remarkable case is *Calcodes aeratus*, a Malayan species (pl. 3, fig. 3). This again has two entirely different types of male, an inconstant phase with a long head and triangular mandibles, with toothed edges in close contact (figs. 3a, 3b), and a constant phase (fig. 3c), with a broad head and mandibles which together almost form a circle, very slender and studded with fine teeth at regular intervals. Specimens of the inconstant phase vary in size from 15 mm. long to about 30 mm., and their mandibles at their maximum are shorter than the head. In the constant phase the mandibles are always much longer than the head and there is practically no variation.

The same phenomenon is found in several other species of *Calcodes*, and perhaps in most of them, but the constant phase may be very rare. A single specimen from the Philippine Is. in the British Museum, described 90 years

ago as *Calcodes dux*, was declared by Leuthner in 1885 to be in his opinion a form of *Calcodes alces*, and this specimen is still, so far as I know, the only example of the constant phase of that species. It seems quite possible that in some species this phase may only appear at long intervals of time.

Other cases of this interesting phenomenon are found in the genus *Dorcus*. *D. biplagiatus* Westw. (pl. 1, fig. 1), is a well-known and widely-distributed Indian Lucanid which exists in many collections, sometimes in considerable numbers. The mandibles of the ordinary male (fig. 1b) are of unusually small size, quite simple and no longer than the head even in the largest specimens. A single specimen in the Calcutta Museum and another in the British Museum (fig. 1a), both of them brought from the Andaman Islands, have mandibles of entirely different form, long and slender, with a tooth near the base, another before the tip, and between them a forked lobe. These specimens differ in no other respect from the normal form.

Of *Dorcus parryi* (pl. 2, fig. 3) I have seen eighty male examples. All but three of these have flat triangular mandibles, in close contact in small specimens, but in larger ones becoming separated at the base while the anterior halves remain in contact (fig. 3c). Of the eighty specimens two belong to the constant phase (fig. 3a) and have quite different mandibles, slender, curved and far apart, meeting only at the tips, the inner edges bearing only a few scattered teeth instead of the close rank found in the inconstant phase. There is also an erect tooth on the upper surface of the mandible, of which no trace appears in the inconstant phase. The third specimen (fig. 3b), which is in M. Oberthür's collection, is highly interesting. Like the two just mentioned, it is of maximum size. The left mandible is that of the rare constant phase, but the right is precisely that of a similar-sized example of the common phase.

In a Bornean species, *Dorcus forceps* (pl. 2, fig. 2), a single specimen in the British Museum also combines the two phases on different sides of the head (fig. 2b), the left mandible here being that of the inconstant and the right that of the constant form.

In *Dorcus faber* (pl. 3, fig. 4), a West African species of which the British Museum contains sixteen male examples, the constant phase appears to be the predominant one, while the inconstant is relatively rare. Thirteen specimens (fig. 4a) of this species have slender curved jaws meeting only at the tips and in only three they are short and flat, with the inner edges in contact (fig. 4b). In this case the specimens of the predominant form vary to some extent in the size, although not in the form, of the mandibles. It seems likely that here the primitive form is being displaced by the later one, which is assuming the character of variability. This seems to me to suggest that those LUCANIDAE, such as the genus *Lucanus*, in which the primitive Priodont type is never found, the mandibles being always widely separated, whatever the degree of development, have passed through that stage, and the earlier form, still predominant in others, has been replaced by the once-rare constant phase.

Other species in which two distinct male phases exactly like those already described may be found are *Calcodes burmeisteri*, *C. delesserti*, *C. sinensis*, *C. lowei*, *C. sommeri*, *C. stevensi*, *Dorcus serricornis*, and *D. antilope*. There are certainly many more in which the two phases exist, and probably some in which they are known by different names.

A single specimen from Assam in the Oxford University Museum (pl. 1, fig. 1a) was described by Hope a century ago under the name *Lucanus spencei*, and I believe that no similar specimen has ever been found. This insect has slender curved mandibles with a single small tooth near the base of each. A species

inhabiting the same region, which was named *Prosopocoelus mordax* by Boileau (pl. 1, fig. 1b), agrees with *spencei* in size, shape, and all else except in having massive serrate mandibles of completely different aspect. Boileau subsequently suggested the possibility that these might be two forms of the same species. Analogy with the nearly related *D. parryi* (pl. 2, fig. 3) makes it fairly certain that this is so. Identity of size in specimens of two phases of the same species can be regarded as evidence that no transitional stages exist, although it is only when a considerable series has been brought together that the absence of connecting links is plainly revealed.

In my opinion another rare Indian form, *Calcodes saundersi*, in which the mandibles are curved and bear an erect tooth at the base, may similarly be regarded as the constant phase of the very abundant *Calcodes baladeva*, in company with which it has been found. *C. baladeva* has the mandibles in close contact and always without trace of the basal tooth.

It may be stated as a general rule that when two such distinct forms of male appear side by side in the LUCANIDAE one is constant and the other variable. Those of the variable phase show every gradation from the smallest to the largest size, the jaws in small specimens are in close contact and not completely symmetrical. Specimens of the constant phase are of full size, their jaws are symmetrical, long, slender, far apart and meet only at the tips. There is no transition from one phase to the other. With few exceptions the constant phase is less abundant than the other; it is sometimes extremely rare and perhaps sometimes occurs only at long intervals of time.

Another kind of dimorphism also occurs in male LUCANIDAE. In certain wide-ranging species local forms are found of which the distinctive features appear only in the male sex and only in large specimens of that sex.

Dorcus giraffa (pl. 3, fig. 5) is an abundant insect in China, the Malay Peninsula, Java and other countries. The mandibles of the male are very long and slender, with numerous teeth distributed at intervals along the inner edge. In the best developed specimens they are almost straight for two-thirds of their length, bent outwards rather abruptly at that point and strongly rounded from there to the tip. A very large tooth is placed at the bend and the tip is forked. This form (fig. 5b) is common in Assam, but is not found in the Darjeeling district, where it is replaced by a form named *Dorcus arrowi* by Gravely (fig. 5a). The large males of this have the mandibles gently and uniformly curved, not forked at the end and without the strong tooth beyond the middle. The first tooth, occurring before the middle and always minute in the Assam form, is the largest in the Darjeeling form. This form has an East and West range from central China and Tonkin to the United Provinces of India. Gravely has stated that the females of the two forms are quite different, but the features which he enumerates as distinguishing the female of *D. arrowi* are all features peculiar to the male sex, and it is evident that he mistook the sex of the specimen described. Actually females from all localities are indistinguishable. All the distinctive features of the two forms are well marked in large males only, feeble in middle-sized individuals and entirely absent in very small specimens.

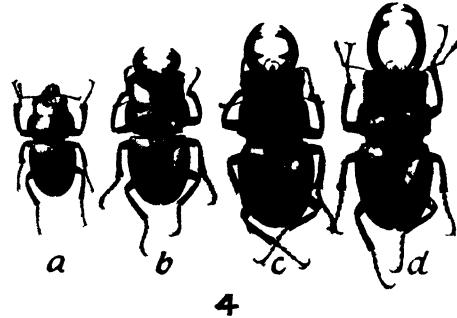
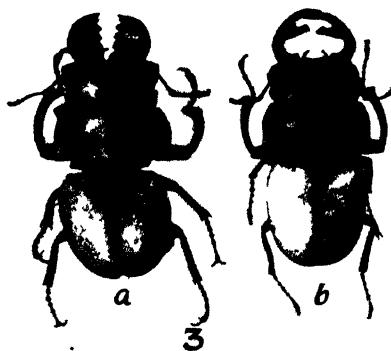
An exactly similar case of local variation in the male only is presented by another Indian species, *Dorcus foveatus* (pl. 3, fig. 6). A supposed distinct species inhabiting the Darjeeling district was described as *poultoni*. Full-sized males of this (fig. 6a) have teeth at intervals along the inner edge of the mandible, one before the middle and another beyond the middle being larger than the rest. Corresponding males from Assam (fig. 6b) have only one large

tooth which occupies a position between those of the two found in the Darjeeling form. The Assam form ranges as far as Upper Burma, but in Lower Burma a form called *birmanicus* is found. This also has only a single large mandibular tooth, which is placed near the base instead of near the middle of the mandible. These local differences exist only in large males. Small ones in all districts have the mandibles finely and closely toothed throughout. Females also are alike everywhere.

Another very common Stag-beetle, *Dorcus titanus*, is found in the East Indian Islands, the Malay Peninsula and India. The name *platymelus* has been given to a form found in China and Japan, which differs in the more slender mandibles of the male. But again this serves to distinguish only males of large size. Less well developed males cannot be separated, and females from all regions are alike.

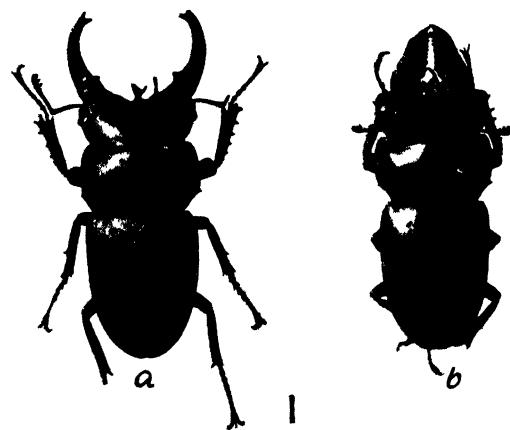
In beetles of the Lamellicorn families the highly chitinized aedeagus of the male often bears teeth and processes, sometimes of rather fantastic development and suggestively like the external horns and mandibular teeth so characteristic of the group. The question naturally arises whether the polymorphism which was long unsuspected in the external male characters can in any degree affect these internal structures also. Some recent authors rely upon their constancy to the extent of basing species upon them, even though no specific difference of any kind can be found in the other sex. There are no doubt groups in which these organs, as well as chitinous external structures, show a great degree of constancy; but, in the Lamellicornia at least they show considerable variability. In 1917, *Fauna of India* (Lamellicornia, 2: pl. 5, figs. 4-10) I have given a series of figures showing striking local variations in the aedeagus in a single wide-ranging species. Curti has also figured (1913, *Ent. Mitt.*, 2: pl. 4, 5) a long series showing the local variation of the same organ in the common Rose-beetle, *Cetonia aurata*. Within a limited area the aedeagus appears to show considerable constancy, but, when studied in specimens from places more and more distant from the centre of an insect's range, more and more divergence of form may appear. This is the case in the Lucanid species just referred to, *Dorcus titanus*. Two pairs of converging spines upon the tegmen are separated by a distance which is found to vary slightly when examples from regions not far apart are examined; but comparison of specimens from countries as far removed as Japan and Assam shows a difference which appears very considerable.

In considering the question of specific differentiation, it appears to me that the relatively constant female of these insects is a better guide than the highly polymorphic male. Those who regard the female as of little importance will no doubt prefer to the conception of a single species with varying male forms that of many species with a single female form. Until there is agreement upon the precise meaning of the term species, both conceptions may be permissible; but while the former enables us to provide every specimen with a specific name, which is the object of the binomial system of nomenclature, the latter has the very obvious practical disadvantage that in many cases it completely fails when applied to one of the two sexes.

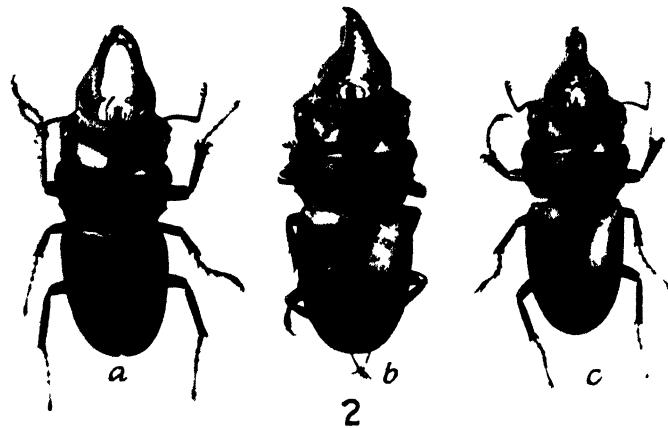


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Dimorphism in male Lucanids.



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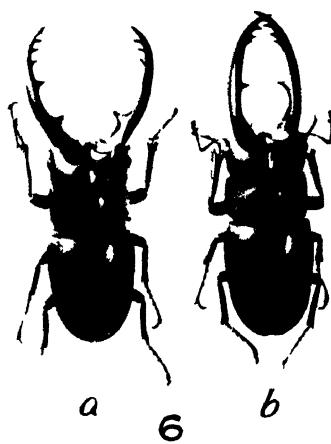
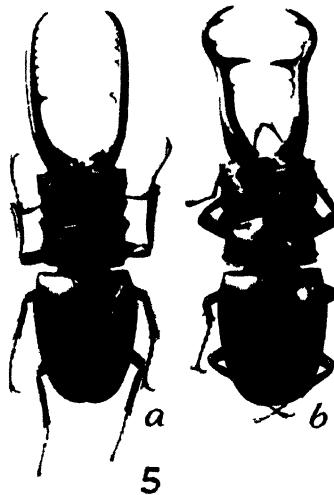
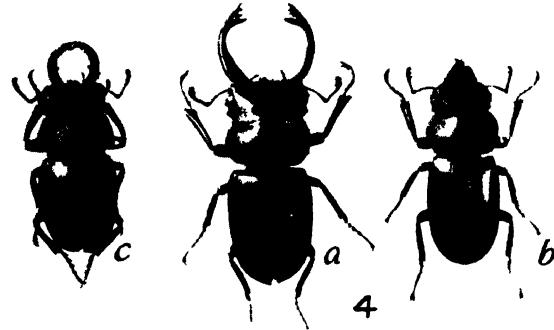
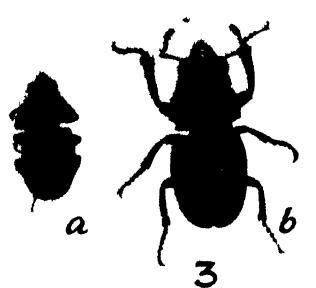
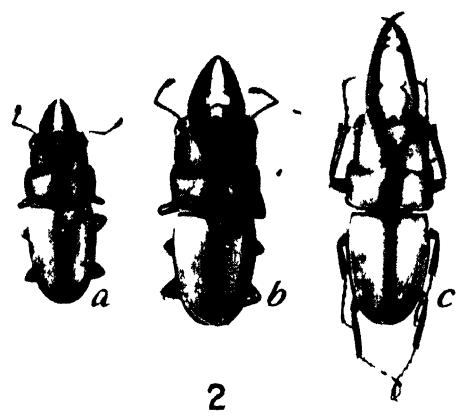
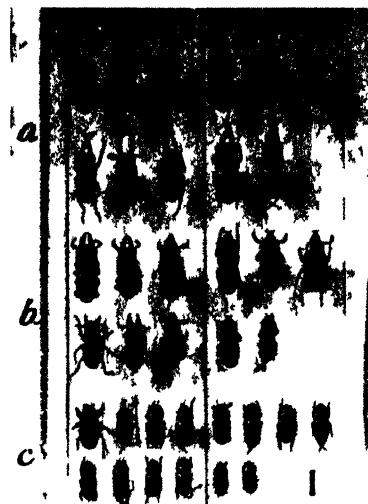
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Dimorphism in male Lucanids.



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Dimorphism in male Lucanids.

EXPLANATION OF PLATES.

PLATE 1.

- FIG. 1. *Dorcus biplagiatus* Westw., natural size. *a.* male, constant phase; *b.* male, variable phase; *c.* female.
2. *Calcodes siva* Hope, natural size. *a.* male, constant phase; *b.* male, variable phase.
3. *Calcodes brookeanus* Voll., natural size. *a.* male, variable phase; *b.* male, constant phase.
4. *Calcodes carinatus* L., reduced. *a, b, c.* males, variable phase; *d.* male, constant phase.

PLATE 2.

- FIG. 1. *Dorcus spencei* Hope, natural size. *a.* male, constant phase; *b.* male, variable phase.
2. *Dorcus forceps* Voll., natural size. *a.* male, constant phase; *b.* male, with both forms of mandible; *c.* male, variable phase.
3. *Dorcus parryi* Boil., natural size. *a.* male, constant phase; *b.* male, with both forms of mandible; *c.* male, variable phase.

PLATE 3.

- FIG. 1. *Dorcus suturalis* Oliv., reduced. *a.* males, constant phase; *b.* males, variable phase; *c.* females.
2. *Dorcus suturalis* Oliv., natural size. *a, b.* males, variable phase; *c.* male, constant phase.
3. *Calcodes aeratus* Hope, natural size. *a, b.* males, variable phase; *c.* male, constant phase.
4. *Dorcus faber* Thoms., natural size. *a.* male, constant phase; *b.* male, variable phase.
5. *Dorcus giraffa* F., reduced. *a.* male, *arrowi* phase; *b.* male, typical phase.
6. *Dorcus foveatus* Hope, reduced. *a.* male, *poultoni* phase; *b.* male, typical phase.

STUDIES ON THE ECOLOGY OF COFFEE PLANTATIONS IN EAST AFRICA. II.

THE AUTECOLOGY OF *ANTESTIA* spp. (PENTATOMIDAE) WITH A PARTICULAR ACCOUNT OF A STREPSIPTEROUS PARASITE

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[Read 5th May, 1937.]

WITH FORTY TEXT-FIGURES AND THIRTY-TWO TABLES.

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INTRODUCTION.

SINCE the researches of Nassonov (1892-93) very little has been added to our knowledge of the biology of Strepsiptera. Moreover, Nassonov's work dealt with species parasitising Hymenoptera and, on account of the habits of their hosts, exact studies on such species are naturally attended with the greatest difficulty:

When therefore I found, early in 1935, a species of Strepsiptera parasitising the Pentatomid *Antestia*, the "Variegated Coffee Bug," which is one of the most serious and widespread pests of coffee in East Africa, the opportunity was taken to make a detailed study of its life-history. This is described in Parts II and III of this paper.

One clearly cannot study a parasite apart from its host, and during the course of my investigations several new facts about *Antestia* were discovered. It therefore seemed desirable to include in this paper a general account of *Antestia*, partly in order to render intelligible the detailed account of its Strepsipterous parasite, but even more because a collation and discussion of the information already gained is an essential preliminary to further work on this pest.

That further work is necessary will be obvious from Part I of this paper. It is especially desirable to obtain more knowledge of the influence of different environmental conditions on the feeding habits of *Antestia* and, in consequence, on the nature and extent of the damage caused.

Acknowledgements. I am indebted to Sir Guy A. K. Marshall and the specialists of the Imperial Institute of Entomology, for identifications of insects. Particularly to Dr. K. G. Blair for describing *Corioxenos antestiae*, and to Mr. W. E. China for identifying and giving other information about the species of *Antestia*. To the staff of the Coffee Experimental Station, Lyamungu, for assistance while I was working there and for sending me collections of *Antestia* when I was unable to go myself. To the entomological staff of the Department of Agriculture, Kenya, for collections of *Antestia* and various information acknowledged in the course of this paper. To Mr. L. R. Doughty, Geneticist of the East African Agricultural Research Station, for advice on the statistical treatment of certain problems, and to Mr. R. E. Moreau, Secretary, for reading over the typescript.

PART I.

THE BIONOMICS AND CONTROL OF *ANTESTIA*.

(1) THE SPECIES OF *ANTESTIA* OCCURRING ON COFFEE IN EAST AFRICA.

There is some difficulty in determining the distribution of the various species of *Antestia* in East Africa, since there has been much confusion in the nomenclature of this genus.

Anderson (1919), referring to the species common in Kenya, wrote: "Until recently, the bug was known as *Antestia variegata* Thunb. var. *lineaticollis* Stål, but Professor Schouteden has, after the examination of much material, come to the conclusion that they are quite distinct and has made *lineaticollis* a separate species. The East African coffee bug is, therefore, now known as *Antestia lineaticollis* Stål."

A. variegata Thunb. has been recorded from coffee in Nyasaland (Ballard, 1913) and in Southern Nigeria (Peacock, 1913), but I think it probable that both these records refer to another species, perhaps *lineaticollis*. The true *A. variegata* occurs in South Africa, where it is a pest of peaches (Lounsbury, 1918).

Gowdey (1918) referred to *A. orbitalis* Westw. var. *faceta* Germ. and *A. orbitalis* var. *lineaticollis* Stål, as occurring in Uganda and Kenya respectively. These two names have been adopted by many authors until recently, in spite of Schouteden's decision (Anderson, *loc. cit.*) and of the fact that ten years ago Hargreaves (1927) concluded that they were distinct species, since he was unable to interbreed them.

I recently sent specimens of five apparently distinct species of *Antestia* to the Imperial Institute of Entomology, and China (*in litt.*, 1936) has informed me that one of them is *A. trivialis* Stål, and, as regards the others, that he has "tentatively determined four 'species' as follows—*A. lineaticollis* Stål; *A. faceta* Germ.; *A. falsa* Schout.; *A. usambarica* Schout. Representatives of the last two have been sent to Dr. Schouteden for comparison with the types, and I am awaiting his reply."

I have myself no doubt that these are five distinct species and not varieties. I have attempted to interbreed them (except *usambarica* with any other and *falsa* with *trivialis*), but always without success. Moreover, as described in Part III, Section 9, they have different relationships with the Strepsipterous parasite *Corioxenos antestiae* Blair.

The colour pattern is variable, but I have not found any specimens definitely

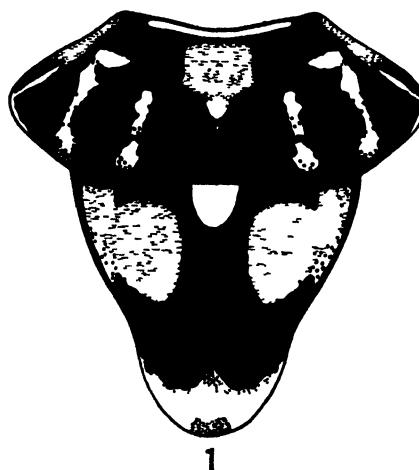


FIG. 1.—*A. lineaticollis*. Pronotum and scutellum. $\times 10$.

intermediate between any two of these species. Diagrams of typical colour patterns of the pronotum and mesothoracic scutellum are given in figs. 1-5. I believe, therefore, that the names and distribution of the East African species are as follows:—

A. lineaticollis Stål (fig. 1). Medium-sized, male about 6.8-7.5 mm., female 7.5-8.5 mm.* Predominant colours of dorsal surface black, orange, and white; rather shining and sharply contrasted owing to the sparse punctuation in the light-coloured areas. The most widespread species. Dominant in most coffee districts of Kenya and Tanganyika, and in the Masaka, Mbarara, Mubende and Toro areas of Uganda (Hargreaves, 1930). Probably occurs in Nyasaland and Northern Rhodesia.

A. faceta Germ. (fig. 2). A small species, male 5.5-6.0 mm., female 6.5-7.0 mm. Colour of dorsal surface dark brown, orange tinged with magenta, and dirty white. The commonest species in the Masindi, Mengo, Buvuma Island and Bugisu districts of Uganda (Hargreaves, *loc. cit.*). Notley (1933) records it from the Nyanza province of Kenya, where it is apparently the dominant, if not the only species. In Tanganyika locally common on Kilimanjaro and in

* The measurements are the length from the apex of the head to the apex of the wings when folded. Exceptionally small or large specimens fall outside the limits given.

the South Paré mountains, but less so than *lineaticollis*. I have only found it in small numbers in the Usambara mountains. Recorded from Nyasaland (Smee, 1931).

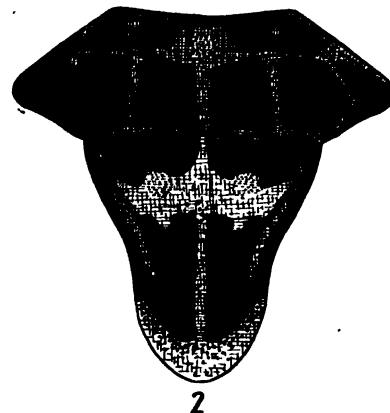


FIG. 2.—*A. faceta*. Pronotum and scutellum. $\times 10$.

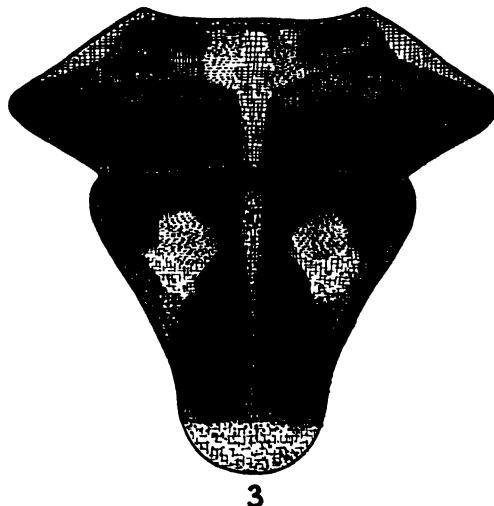


FIG. 3.—*A. falsa*. Pronotum and scutellum. $\times 10$.

A. falsa Schout. (fig. 3). Similar in colour to *faceta*, the orange parts rather more strongly tinged with magenta. Considerably larger, male about 8.3–8.8 mm., female 9.0–9.5 mm. I have found this species only in the South Paré mountains, where it was not common. I know of no other records from East Africa. I have been informed by Mr. J. M. Vrijdagh that it occurs in the Belgian Congo.

A. trivialis Stål (fig. 4). A large species, male 9.0–9.5 mm., female 10.0–10.7 mm. Predominant colour of dorsal surface olive brown; scutellum tinged with greenish-brown, its apex pale yellow; corium tinged purplish-brown.

Although the adult is so conspicuously distinct from any of the other species mentioned here, the immature stages are very similar, being mainly black, orange, and whitish. Not uncommon, though never abundant, in the East Usambara mountains. There are apparently no other records from East Africa.

A. usambarica Schout. (fig. 5). A large rather elongate species, male 9·5–10·0 mm., female 10·5–11·0 mm. The dark areas almost black, the pale markings yellow with at most a slight trace of orange, sometimes rather greenish-yellow. So far as is known, confined to the East and West Usambaras. I have only obtained a single specimen and have therefore been unable to make any experiments or observations on it. Both this species and *trivialis* were first taken by Morstatt (1912), though their names were not then determined. There are several specimens of both in the old German collection at Amani.

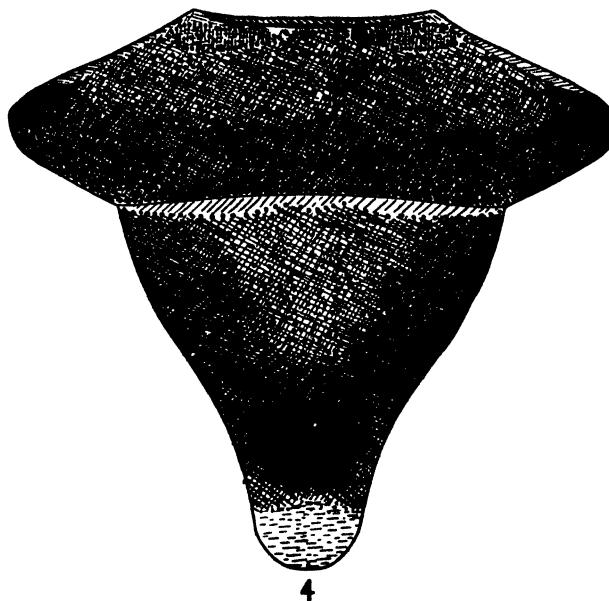


FIG. 4.—*A. trivialis*. Pronotum and scutellum. $\times 10$.

In addition to these five species Hancock (1926) recorded *A. cincticollis* Shaum. on *Canthium* sp. (Rubiaceae) in Uganda. Though not yet found on coffee, it should perhaps be regarded as a potential pest.

Three other species of the genus have been recorded on coffee in other parts of the world. *A. clymeneis* Kirk. (vars. *galtiei* Frappa and *flaviventris* Frappa) is found in Madagascar (Frappa, 1933). This author states that this species feeds on both green and red coffee berries and in the laboratory also on fresh leaves. Injured berries usually turn black and drop.

A. partita Walk. (= *plebeia* Voll.) is said to be an important coffee pest in Java (Schumacher, 1919).

A. cruciata F. is recorded as attacking coffee in the Nilgiri hills in India (Fletcher, 1913).

(2) LIFE-HISTORY.

Much information has already been obtained by Anderson (1919) in Kenya, and by Gowdey (1918), Wilkinson (1924) and Hargreaves (1930, 1936) in

Uganda. It is therefore only necessary to give here a summary of the life-history, adding certain details not mentioned by these authors.

My own observations were made on bugs kept in the laboratory, each separately in a small celluloid cylinder, standing on blotting-paper and covered with a glass plate. They were fed on full-sized but still green coffee berries. The influence of other food on the duration of the life-cycle and on fecundity is discussed in Section 3.

The eggs are laid in batches, most often of 12, sometimes of 11 or 13. Anderson records several batches of 10 and one of 15. The last one, or two, batches laid before a female ceases ovipositing are often incomplete, consisting only of 4-6 eggs. Anderson also found that the first batch was occasionally incomplete.

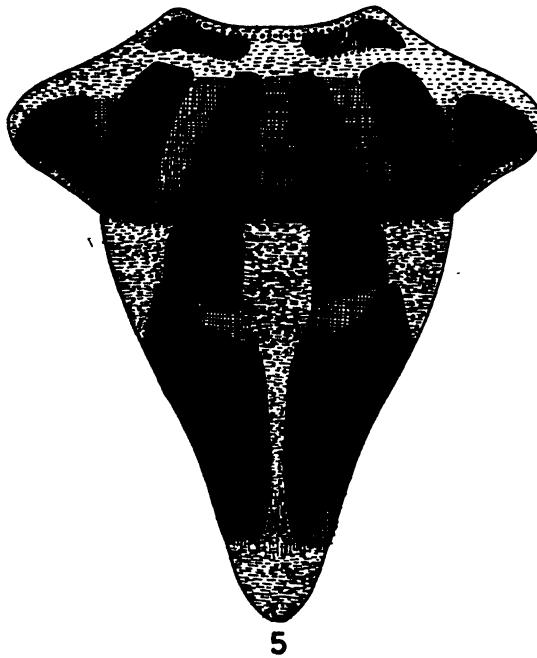


FIG. 5.—*A. usambarica*. Pronotum and scutellum. $\times 10$.

I have found that fertilised females, unless they are disturbed during the process, invariably lay their eggs in the manner precisely described by Wilkinson. Unfertilised females, however, often scatter their eggs at random.

The eggs are usually * laid on the under surface of a coffee leaf, sometimes on a berry or on other parts of the plant. Wilkinson records eggs on other plants growing near coffee, on tree trunks, and on the verandah of a house. It is improbable that nymphs hatching from eggs laid in such places would survive.

The number of eggs laid by a female is very variable. Anderson records one female that, during a period of 256 days, laid 41 batches totalling 485 eggs. The average he gives, for 61 bugs, is 126 eggs during a period of 89 days. My own records, at Amani, show an average of 13 batches laid by each fertilised

* According to Anderson, 90%.

female. This is slightly greater than Anderson's average; on the other hand, none of my females laid more than twenty batches. Hargreaves in Uganda has recorded over 300 eggs laid by one female.

I have found that unfertilised females lay only from one to four batches of eggs, though they may live for several months after ceasing to lay. Wilkinson records that females isolated after copulation never laid more than two batches. One of my females, however, laid four batches of fertile eggs during a period of 30 days after it had been segregated from a male.

The duration of the egg stage varies with the temperature. Anderson, at Kabete (6000 ft.) in Kenya, recorded 7-9 days during January to April and 13-15 days during May to December. Both Wilkinson and Hargreaves state that at Kampala (3900 ft.) in Uganda the period is between 4 and 9 days. My own records at Amani (3000 ft.) in Tanganyika vary from 5-6 days in February and March (average temperature 23.5°) * to 8-10 days in June to August (average temperature 19.2°).

Most of my own observations on the duration of the egg stage, as also, I believe, those of the other authorities quoted, were made under laboratory conditions. I have, however, several times compared the incubation period of eggs kept in the laboratory with that of eggs in the normal position on the under surface of a leaf of a coffee bush growing in the open, and I have never found a difference of more than a few hours.

The proportion of (unparasitised) eggs hatching in the field is, as stated by Wilkinson, very nearly 100%. I have found that under laboratory conditions, also, almost all the eggs laid by fertilised females are viable. All the eggs of one cluster hatch on the same day, and usually within two or three hours.

After eclosion the first-instar nymphs remain close to their empty egg-shells for about the first half of the stadium. Later they move away and begin to feed. They are, however, able to undergo the first ecdysis without having fed at all, though the mortality is then high. Only 12 out of 48 to which I gave no food during the first stadium moulted and survived.

With very few exceptions I have found that all the nymphs from one egg-batch moult to the second instar on the same day. Wilkinson, however, recorded several that varied by two or three days.

Tables 1-5 summarise the available data on the duration of the five stadia under laboratory conditions. (The records of Anderson and Wilkinson, as well as my own, show that there is no difference in the developmental period of the sexes.) Fig. 6, based on my records at Amani, shows how the period of development from egg to adult varies with the temperature.

A few experiments, made in an incubator, suggest that constant and rather high temperatures may have a retarding effect on development. However, only the duration of the fourth and fifth stadia was recorded, and the number of bugs in each experiment (seven) was perhaps insufficient. At an almost constant temperature of 30.0° the average duration of the fourth and fifth stadia together was 28.2 days; at 26.5°, 27.5 days; at 24.0°, 24.8 days; and at

* All temperatures in this paper are given in degrees centigrade. The figures for average temperature were obtained from mercury-in-steel thermographs, checked frequently by an aspirated thermometer. They are $\frac{\text{max.} + \text{min.}}{2}$ after the application of a correction factor. The correction factor was obtained by summing the hourly temperatures on four or five days (chosen at random) in each month and dividing by 24. If the resulting average differed from the $\frac{\text{max.} + \text{min.}}{2}$ for the same days this correction was applied to the whole month. It was never greater than - 0.4°, and was frequently nil.

TABLE 1.
Antestia lineaticollis.
The duration of the first stadium.

Authority	Locality	Time of year	Average temperature	Mean duration (days)	Extremes
Gowd ey	Kampala	Apr.	—	12	10-14
Wilkinson	Kampala	Sep.-Nov.	—	5.9	4-8
"	"	Nov.-Feb.	—	5.0	3-9
Anderson	Kabete	Feb.-Apr.	—	5.8	5-7
"	"	June-Aug.	—	15.1	10-18
Kirkpatrick	Amani	Sep.-Feb.	—	9.2	6-10
"	"	Dec.-Jan.	22.9-23.6	5.8	5½-6
		May-June	20.8-21.7	8.0	7-9

TABLE 2.
Antestia lineaticollis.
The duration of the second stadium.

Authority	Locality	Time of year	Average temperature	Mean duration (days)	Extremes	Standard deviation	Standard error of mean
Gowd ey	Kampala	Apr.-May	—	14	14-16	—	—
Wilkinson	Kampala	Sep.-Nov.	—	6	5-13	—	—
"	"	Nov.-Feb.	—	12.6	4-19	—	—
Anderson	Kabete	Feb.-Apr.	—	11.2	10-16	—	—
"	"	July-Sep.	—	33	11-47	—	—
Kirkpatrick	Amani	Oct.-Feb.	—	20	18-28	—	—
"	"	Jan.	23.1	9.4	9-11	0.58	0.13
		May-June	21.3	13.6	11-22	4.55	0.57

TABLE 3.
Antestia lineaticollis.
The duration of the third stadium.

Authority	Locality	Time of year	Average temperature	Mean duration (days)	Extremes	Standard deviation	Standard error of mean
Gowd ey	Kampala	May	—	15	13-16	—	—
Wilkinson	Kampala	Sep.-Nov.	—	10.5	7-16	—	—
"	"	Nov.-Feb.	—	11.3	6-23	—	—
Anderson	Kabete	Feb.-Apr.	—	8.0	5-11	—	—
"	"	Aug.-Oct.	—	22.5	8-66	—	—
Kirkpatrick	Amani	Nov.-Mar.	—	15.8	13-27	—	—
"	"	July (L), Aug. (L)	19.8-20.4	13.4	10-18	4.7	0.79
"	"	May (L), June (L)	20.8-21.7	12.9	10-19	4.7	0.81
"	"	Apr. (V)	—	—	—	—	—
"	"	Apr. (L), Oct. (L)	21.9-22.6	12.4	10-20	3.3	0.61
"	"	Nov. (V), Dec. (V)	—	—	—	—	—
"	"	Jan. (L), Feb. (L)	22.9-23.6	10.4	6-15	3.7	0.74
		Jan.-Mar. (V)	—	—	—	—	—

(L) = in laboratory; (V) = on enclosed verandah.

TABLE 4.

Antestia lineaticollis.

The duration of the fourth stadium.

Authority	Locality	Time of year	Average temperature	Mean duration (days)	Extremes	Standard deviation	Standard error of mean
Gowdey Wilkinson	Kampala	May-June	—	17	15-20	—	—
	Kampala	Sep.-Nov.	—	10.8	7-26	—	—
	"	Nov.-Feb.	—	12.9	7-20	—	—
	"	Feb.-Apr.	—	8.3	6-10	—	—
Anderson	Kabete	Sep.-Dec.	—	22.5	13-59	—	—
		Dec.-Mar.	—	13.0	8-19	—	—
Kirkpatrick	Amani	June-Sep. (V)	18.9-19.5	17.6	10-27	6.75	0.75
		July-Sep. (L)	19.8-20.4	14.8	10-24	8.6	0.98
		May (V)					
		May (L), June (L)	20.8-21.7	14.7	10-29	7.3	0.85
		Apr. (V), Oct. (V)					
		Apr. (L), Oct. (L)	21.9-22.6	11.9	5-23	5.7	0.80
		Nov. (L), Nov. (V)					
		Dec. (V)					
"	"	Dec.-Feb. (L)	22.9-23.6	10.5	7-17	4.55	0.43
		Jan.-Mar. (V)					

(L) = in Laboratory; (V) = on enclosed verandah.

TABLE 5.

Antestia lineaticollis.

The duration of the fifth stadium.

Authority	Locality	Time of year	Average temperature	Mean duration (days)	Extremes	Standard deviation	Standard error of mean
Gowdey Wilkinson	Kampala	June-July	—	17	15-20	—	—
	Kampala	Sep.-Nov.	—	15.0	11-21	—	—
	"	Nov.-Feb.	—	15.9	7-27	—	—
	"	Feb.-Apr.	—	12.8	10-22	—	—
Anderson	Kabete	Sep.-Dec.	—	22.3	8-37	—	—
		Dec.-Apr.	—	16.9	15-25	—	—
Kirkpatrick	Amani	June-Sep. (V)	18.9-19.5	22.0	17-40	2.24	0.21
		July-Sep. (L)	19.8-20.4	19.3	15-35	5.0	0.47
		May (V)					
		May (L), June (L)	20.8-21.7	18.1	13-26	6.6	0.64
		Apr. (V), Oct. (V)					
		Apr. (L), Oct. (L)	21.9-22.6	16.7	11-26	6.86	0.54
		Nov. (L), Nov. (V)					
		Dec. (V)					
"	"	Dec.-Feb. (L)	22.9-23.6	14.7	11-23	6.17	0.49
		Jan.-Mar. (V)					
		Mar. (L)	24.1	13.0	11-23	4.71	0.75

(L) = in Laboratory; (V) = on enclosed verandah.

22.5°, 27.7 days. This last figure is in close agreement with that found in the laboratory when the temperature averaged the same, but had a range of about 3.5°. At the higher constant temperatures the duration is longer than would be expected.

I believe that the duration of the nymphal stages, under the conditions in which they were kept in the laboratory, approximates closely to that under field conditions. Twenty nymphs, hatched on 22. ix. 36, were put on a branch of a coffee plant bearing leaves and green berries and kept completely unprotected out of doors. The branch was placed in water and changed every few days. Only six survived to become adult, the rest having disappeared. The average time from hatching to adult of these six was 55 days, the extremes being 48 and 59 days. Twenty-two nymphs, hatched on the same day and kept in the laboratory, all survived to maturity. The average period was 54.5 days, the extremes 48 and 63 days.

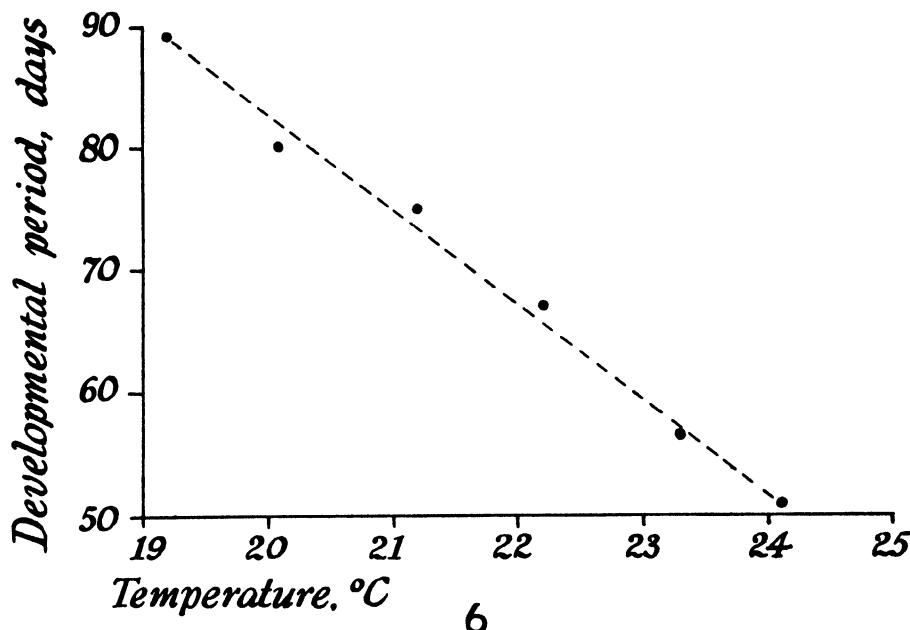


FIG. 6.—The period of development from egg to adult of *Antestia lineaticollis*, according to the temperature.

In coffee plantations both nymphs and adults avoid positions exposed to the sun during the middle of the day. Most remain in the interior of the bush or on the shaded side of berries or leaves. In the early morning and the evening, and throughout cool sunless days, they are more often found on exposed parts of the bush. When nymphs are approached they usually dodge round to the other side of the berry or leaf on which they are sitting, or hide in a cluster of berries. Adults when disturbed sometimes drop to the ground, but they often fly away, especially in warm and sunny weather. But they seldom, if ever, fly unless disturbed.

Under field conditions females are rather more numerous than males. Wilkinson, in Uganda, found 42.5% males and 57.5% females. At Lyamungu, in Tanganyika, I found 38.6% males and 61.4% females. Both Wilkinson and I have found that among bugs bred in the laboratory the proportion of males is somewhat higher, Wilkinson's figure being 52.4% and mine 48.6%.

The period that elapses from the female becoming adult to laying its first eggs is given by Wilkinson, at Kampala, as 8 to 16, with an average of 13 days.

Anderson, at Kabete, recorded 13 to 36 days, with an average of 19. The latter is in close agreement with my own records at Amani.

Wilkinson concluded that copulation took place during the night. I have myself never seen *A. lineaticollis* copulate before 16 h., but from then until dusk they frequently do.

The average duration of adult life is shown in Table 6. It will be seen that females tend to live rather longer than males. Both Anderson and I have recorded bugs of both sexes that lived for more than twice the average period. Thus Anderson kept a female alive for 290 days and a male for 249 days, and I have recorded 245 and 322 days respectively. This last figure is quite exceptional; the bug was, moreover, stylopised; it contained one male *Corioxenos*, yet it lived for 281 days after the emergence of this parasite (cf. Part III, Section 3). The next longest-lived male kept by me lived only for 197 days.

The duration of life recorded by Gowdey and Wilkinson in Uganda is surprisingly short. Hargreaves (1930, 1936), however, though he does not quote an average figure, states that in Uganda adults may live for eight months, which is in much closer agreement with other records.

The complete life-cycle, in the various localities where it has been observed, is summarised in Table 6.

TABLE 6.

Summary of the life-cycle of *A. lineaticollis*.

Authority	Locality	Time of year	Average number of days from egg to adult	Average duration of adult life		Average number of eggs laid by each female	
				Males	Females		
Gowdey Wilkinson	Kampala	Mar.-July	84	16	16	—	
	Kampala	Sep.-Nov.	55	—	—	—	
	"	Nov.-Feb.	64	57	57	106	
	"	Feb.-Apr.	52	—	—	—	
Anderson	Kabete	Jun.-Dec.	128	—	—	—	
	"	Sep.-Apr.	84	106	131	126	
Kirkpatrick	Amani	Apr.-June	77	103	127	148	
	"	July-Sep.	72		121		
	"	Oct.-Nov.	62	98	121		
	"	Dec.-Mar.	56				

It is naturally difficult to say how the length of life in the laboratory compares with that in the field. I have kept adults on a coffee bush, covered with mosquito netting but otherwise fully exposed to the weather, and more than half survived for three months and many for six months.

The foregoing account refers to *A. lineaticollis*, but so far as my observations go the life-history and habits of *faceta*, *trivialis* and *falsa* are exactly similar except in the following minor particulars. The duration of the nymphal stages of *trivialis* and *falsa* is on the average a few days longer, and of *faceta* a few days shorter, than of *lineaticollis*. But my records, especially of the earlier stadia, are insufficient to be quite certain that the difference is significant. Both *faceta* and *trivialis*, in contrast to *lineaticollis* and *falsa*, will copulate readily at any hour of the day. The feeding habits of these three species appear to be exactly the same as those of *lineaticollis*. These are discussed in the following section.

(3) FOOD AND FEEDING HABITS.

(a) Host plants.

All authorities are agreed that arabica coffee is the principal host plant of *Antestia*. Hargreaves (1936) has recorded it living and breeding on three species of *Canthium* (Rubiaceae), but states that "the bug shows no preference for *Canthium* in the vicinity of *Coffea arabica*." He has also on one occasion found a few nymphs on robusta coffee, but considers that it cannot be regarded as a food plant. I have failed to keep either nymphs or adults alive for more than a few days when they were provided only with robusta berries. LePelley (1934) has found *A. lineaticollis* breeding on *Psychotria nigropunctata* Hiern (Rubiaceae) in the Kiambu district of Kenya.

Both Gowdey (1918) and Wilkinson (1924) record having found the bug on several other plants besides coffee, but, as the latter author states, there is no evidence that it was feeding on any of them. It can, I think, be considered certain that *Antestia* will breed only on plants of the order Rubiaceae, and that arabica coffee is by far the most favourite host plant.

(b) The parts of the coffee plant on which *Antestia* feeds.

Some divergence of opinion has been expressed concerning the parts of the coffee plant on which *Antestia* is able, or prefers, to feed. Gowdey (*loc. cit.*) stated that "they suck the berries, the newly set as well as the well-developed berries. . . . When neither flowers nor fruit are available the newly hatched nymphs seem to prefer the foliage, though they will also puncture the tender shoots, such as suckers. . . . Although I have reared the bug to the adult stage exclusively on tender leaves, there is no doubt that flowers and fruit are preferred, and they can only with difficulty be induced to feed on mature leaves."

Anderson (1919) wrote: "The favourite food of the adult is the green berry [he does not state of what age]; if these are not available the buds are next attacked; nourishment can also be obtained from the delicate green twigs; the leaves are the last resort; I have not been able to keep the adult bugs alive for any length of time, on leaves (young or old) alone."

Wilkinson (*loc. cit.*) said that "there is a remarkable preference for the developing green berry. . . . Next to green berries the delicate shoots are the favourite feeding place especially at, or near, a node, that is, the part of the twig from which a pair of leaves spring. . . . The leaves are the last resort. That food can be extracted from the leaves is shown by the fact that adults have been kept alive for several weeks on leaves only, both young and old, whereas adults given no food at all died within two days. Adults have also been kept alive on ripe berries but not on berries when the bean was almost solid and the skin green and hard, which is the condition just previous to the berry becoming ripe."

Hargreaves (1936) wrote: "The feeding habit of the adult is much the same as that of the nymph; young berries in which the beans are still soft being preferred. Ripe berries also are attacked, but the beans are then too hard for the bug's proboscis to penetrate, and no appreciable damage is done to the crop. . . . Feeding experiments have indicated that berry-food is essential for the reproduction of the bug, and that egg-laying is most prolific during the first four months of the development of the berry, while the beans are still soft. After this stage (in the presence of an even-aged crop) bug reproduction falls off. . . . The more nearly mature and ripe

berries are also attacked by the bug, but the feeding appears to be restricted to parts other than the seeds. Flower buds may also be sucked. In the absence or scarcity of berries, the young shoots are liable to attack."

Notley (*in litt.*, 1936) stated that in Kenya Naismith-Jones "had no difficulty in raising *Antestia* from egg to adult on leaves and stems only, though the death rate was, he thinks, higher than on cherry. He found that the secret of raising *Antestia* is to supply any amount of water: spraying the leaves thoroughly with water as much as three times a day during hot weather was best."

In all my own experiments, apart from those detailed in this section, I have fed the bugs of all stages exclusively on full-sized but still green berries of which the endocarp (parchment) was already hard. In many, though not all, of the berries used the endosperm (bean) had become white and "cheesy," which is the condition it assumes shortly before the berry begins to turn red. Water was given to some of them during the dry season, but was found to be unnecessary. With this food I have reared several thousand bugs from egg to maturity and oviposition. The mortality, calculated from 30 egg-batches (but excluding two of which all the nymphs died within 24 hours of hatching, *i.e.* before they had fed), was about 15% during the first stadium, about 5% during the second, and about 3% during each of the third, fourth and fifth stadia. Thus nearly 75% of the bugs that hatched survived to maturity.

In the experiments of Wilkinson (1924), in which apparently young green berries were given as food, of 617 nymphs that hatched 13, 33, 22, 12 and 8% died during the respective five stadia, and only 37% became adult.

Seeing that my own experience differed from that of former workers, I made a few simple experiments on the influence of different parts of the coffee plant on development, reproduction and longevity.

(c) *The effect on the life-cycle of Antestia of feeding them on different parts of the coffee plant.*

Table 7 compares the life-cycle when the food given was (a) full-sized green berries, about four to six months after flowering, of which the parchment was hard, (b) half-grown green berries, about two to three months after flowering, of which the parchment was still soft, (c) ripe red berries. (At Amani, the berry is ripe about seven months from the date of flowering.) Ten egg-batches were used, three nymphs from each being fed on each of the three classes of food (two extra on the ripe berries). The bugs were kept in the laboratory, each separately, all other conditions were similar and no water was given.

The duration of the first stadium was the same, eight days, for all the bugs. The small amount of food taken towards the end of the first stadium has, therefore, no effect on its duration.

Premature deaths, before the bugs became adult, are shown in Table 8. The only figure significantly* different from the normal mortality is that for the large number of deaths during the second stadium of the nymphs fed on young green berries.

* To verify this, I repeated this part of the experiment during a warmer time of the year. Twenty-five nymphs moulted to the second instar on 29.xii.36. (a) 12 of these were fed on old green, and (b) 13 on young green berries. Of (a) 1 died during the second stadium, which was completed by the 11 survivors in 9 days (2), 10 days (3) and 12 days (6). Of (b) 10 died during the second stadium, which was completed by the 3 survivors in 11 days (1) and 14 days (2).

It is clear from Table 7 that full-sized green berries were a more suitable food than either ripe or young berries, for when either of the two latter were fed the period of development was increased, the length of adult life decreased, and the fecundity of the females greatly reduced. In each case the difference was statistically significant.

TABLE 7.

The influence on the life-history of *A. lineaticollis* of feeding them on coffee berries of different ages.

Nature of food	Mean duration of stadia						Av. duration of adult life		Av. no. of eggs laid by each fertilised female
	1st	2nd	3rd	4th	5th	Aggregate	Males	Females	
(a) Old green berries . n = . .	8.0 24	14.1 23	12.8 22	14.5 20	20.7 19	70.1 19	113 8	132 11	140 8
(b) Young green berries . n = . .	8.0 26	16.7 15	16.2 15	19.2 13	28.4 10	88.8 10	34 5	84 6	12 4
(c) Ripe red berries . n = . .	8.0 29	17.2 28	19.3 27	20.5 26	25.4 25	90.4 25	53 11	78 14	40 9
Difference between means of (a) and (b) .	0.0	2.6	3.4	4.7	7.7	18.7	79	46	128
Standard error of difference between means .	± 0.0	± 1.70	± 1.23	± 1.10	± 2.42	± 3.10	± 15.6	± 20.9	± 16.3
Difference between means of (a) and (c) .	0.0	3.1	6.5	6.0	4.7	20.3	60	54	100
Standard error of difference between means .	± 0.0	± 0.96	± 0.85	± 1.09	± 1.20	± 2.93	± 16.5	± 10.3	± 18.4

TABLE 8.

Deaths of *Antestia* during the nymphal stadia.

Nature of food	Number of eggs hatched	Deaths during					Survived to adult instar
		1st stadium	2nd stadium	3rd stadium	4th stadium	5th stadium	
(a) Old green berries .	30	6	1	1	2	1	19
(b) Young green berries .	30	4	11	0	2	3	10
(c) Ripe red berries .	32	3	1	1	1	1	25

The experiment was repeated (for the duration of the nymphal stadia only) during a slightly cooler time of the year, with a smaller number of bugs. The results were very similar and again showed a significant difference in favour of (a) old green berries over (b) young green and (c) ripe berries. The mean developmental period for five bugs fed on (a) was 77.6 days; for three fed on (b), 93.0 days; and for nine fed on (c), 95.0 days. Comparing these means by the method described by Fisher (1928 : 107) the difference between (a) and (b) is 15.4 days; $t = 4.45$, which for $n - 2 = 6$ gives a value for P of less than 0.01. Similarly the difference between (a) and (c) is 17.4 days; $t = 5.2$, which for $n - 2 = 12$ is nearly double the corresponding 0.01 value of P .

In order to learn whether the bug actually feeds on the hard bean or only on the pulp, I fed a pair of fourth-instar nymphs on beans from full-sized green berries, from which all the skin and pulp was removed. Water was supplied daily. These nymphs became adult and the female laid eggs. There was a large mortality among the young nymphs (fed in a similar way), but three survived to the fourth instar and one to the fifth. Of another batch of eleven nymphs fed in the same way, nine died during the first stadium, two survived to the fourth stadium and one became adult, but died 18 days later. Although, therefore, I was unsuccessful in raising a complete generation from egg to egg on beans only, it is clear that the bugs are able to extract nourishment from them.

Additional proof of this was obtained from the following experiments:—

(1) 24 lots, each of five green coffee berries, were weighed to the nearest centigram. The berries were full-sized, the endocarp hard, and the endosperm white and cheesy. To reduce the loss of weight from evaporation during the course of the experiment, the berries were kept for 48 hours after being picked before they were weighed. The average weight of each lot was then 5.33 grams. On each of 12 lots 10 adult *Antestia* were placed; no water was supplied. The remaining 12 lots were kept under otherwise identical conditions as controls. After 48 hours they were weighed again. The controls had lost an average of 13.9% of their weight, and the berries that had been fed on 22.2%. The standard error of the difference of 8.3% was 0.59.

(2) From 10 lots each of 5 similar berries all the skin and pulp was removed. The average weight of each lot was then 3.47 grams. After 48 hours 5 controls had lost 16.5% of their weight, and 5 lots fed on, each by 10 adult bugs, 26.5%. The standard error of the difference of 10.0% was 1.5.

(3) Bugs were also enclosed with weighed quantities of the skin and pulp removed from similar green berries. The average increase in loss of weight of the lots fed on over the controls was 2.0% after 48 hours, but this was not statistically significant.

Judging, however, from the appearance of the excreta I think that the bugs can extract a small amount of nourishment from the pulp in the absence of the bean.

To ascertain whether *Antestia* has any preference for berries of different ages, I kept twenty (four of each instar from the second to adult) together in one cage, and supplied them with full-sized green berries, half-grown green berries, and ripe red ones. Twenty-five observations were made at different times of the day, during a period of twenty days, and Table 9 shows the average, maximum and minimum numbers observed to be sitting on each class of berry. Though I cannot be certain that all the bugs sitting on a particular class of berry were actually feeding, the results are a strong indication that they prefer nearly mature green berries.

I have failed to keep either nymphs or adults alive in the laboratory when fed only on leaves, flower buds, or very young berries (about two to three weeks from flowering). These foods were kept fresh in water and changed frequently, so there is no question of their having been unsuitable because they had dried up. I have also tried, for experiments on leaves, small plants growing in pots, but on these also all the bugs died within at most fifteen days. When, however, they were kept out of doors and entirely unprotected, I have reared them to the adult stage on similar potted plants bearing leaves only. Eighteen nymphs, hatched on 22.ix.36, were placed on such a plant, and for comparison twenty, hatched on the same day, on a branch bearing

full-sized green berries only, all leaves being removed. This was kept fresh in water and changed when necessary, about every seven days. It was placed in a similar exposed position to the potted plant. From both of these many of the bugs disappeared, but the development of those that remained is shown in Table 10, from which it will be seen that development was slower on leaves than on berries.

TABLE 9.
Food preference of *Antestia*.

	The number of bugs observed to be sitting on			
	Full-sized green berries	Half-grown green berries	Ripe red berries	Elsewhere in cage
Average of 25 observations .	7	1	1	11
Maximum (at any one observation) .	13	4	3	15
Minimum . .	2	0	0	4

TABLE 10.
The development of *Antestia* on a plant bearing leaves only, compared with that on full-sized green berries.

Number of days after eggs hatched	Number and instar of bugs still remaining	
	On leaves	On berries
30	3 in 3rd; 3 in 2nd	11 in 4th; 1 in 3rd
36	1 in 4th; 5 in 3rd	2 in 5th; 7 in 4th
49	3 in 5th; 2 in 4th	2 adult; 7 in 5th
53	4 in 5th; 1 in 4th	3 adult; 3 in 5th
59	2 adult; 3 in 5th	6 adult. —
67	5 adult. —	— —

The reason why they were able to survive on leaves only when kept out of doors, but not in the laboratory, may be that in the former place the leaves were wet almost every night with dew, and frequently by day with rain, and that water is essential when berry food is not given. This is supported by observations made by Naismith-Jones in Kenya (Notley, *in litt.*, quoted above).

All the foregoing experiments were made with *A. lineaticollis* only. Though I have made no comparative trials on the effect of different foods on *A. faceta*, *trivialis* and *falsa*, I have reared all these three species from egg to egg on full-sized green berries only, without the slightest difficulty. I found, however, that *faceta* had a greater mortality during the first and second stadia than any of the other three species.

(d) *Summary and conclusions.*

Summarising the results of feeding experiments, it appears that at Amani *

* I have also successfully reared *Antestia* on old green berries at Lyamungu, though I did not make any comparative experiments there.

the most suitable food for *Antestia* is full-sized green berries, that they can exist on half-grown berries (but not on very young ones nor on flower buds) and on fully ripe ones, and also, but only in the open, on leaves.

At Kampala, in Uganda, the best food is young berries before they are half grown, and the bug will not exist on green berries of which the bean is solid, nor on leaves.

In Kenya the best results are obtained by feeding them on the younger green berries; they cannot feed on the older green berries, but they are able to do so on leaves.

Further investigations on the food habits of *Antestia* are obviously desirable, for the amount of damage done to the crop is largely dependent on the part of the coffee plant attacked.

I suggest that the apparent discrepancies might be accounted for by differences in atmospheric humidity. The climate of Amani is damper and somewhat cooler than that of Kampala, and much damper but rather warmer than that of the Nairobi district. In the absence of comparable meteorological data for the exact situations in which the bugs were bred, I should expect the saturation deficiency to be much less at Amani than at either Kampala or Nairobi. This may possibly explain why at Amani the bug readily feeds and breeds on the comparatively dry food of almost ripe beans, when it is unable to do so in the other two localities.

Moreover, Notley, as quoted above, states that in Kenya it is almost essential to give an abundant supply of water to the bugs. At Amani it is quite unnecessary to supply water when full-sized green cherries are given as food, though there are indications that it is necessary when leaves only are provided.

(4) THE DAMAGE CAUSED.

As described in Section 3, different views have been expressed concerning the part of the coffee plant most usually fed on by *Antestia*. It is therefore not surprising that there is an almost equal diversity of opinion on the nature of the damage done. It will be convenient to discuss this question under the following heads :—

(a) *Damage to the flower buds, with consequent failure of the flowers to set, or shedding of the young berries.*

Gowdey (1918) stated that "there is no doubt that the Variegated Bug is responsible for the non-setting of flowers," though he emphasises that it is only one of several causes. Anderson (1919) also considered that "next to green berries the developing buds are the favourite feeding places. The puncturing of the buds retards their development with the result that fewer flowers are formed and there is a corresponding reduction in the amount of fruit produced."

Wilkinson (1924) "is prepared to admit that *Antestia* may prevent a certain number of flowers from setting, or may cause small berries to fall, but the loss from these causes is almost negligible as compared with other forms of damage."

Hargreaves (1930, 1936), though he mentions that flower buds may be sucked, does not refer to any damage done to them, or to resulting berry fall.

LePelley (1932) in describing the abortion of flowers caused by *Lygus simonyi* Reut. [= *Lygus coffeeae* China] discusses other causes that produce similar results, but does not mention *Antestia* as one of them.

My own opinion, based on observations in the districts of Kiambu, Moshi and Amani, is that *Antestia* seldom sucks flower buds except in the absence of all berries of whatever age. Whether it then causes abortion or shedding I am unable to say for certain, but believe that it does so, if at all, only to a negligible extent. I have, at Amani, liberated large numbers of adult *Antestia* on to a small coffee bush bearing flower buds but no berries, but within a few days all left the bush for a neighbouring one on which there were berries, and I found no trace of damage to the buds. I have only once (in Kiambu) found *Antestia* common on bushes that were bearing numerous flower buds but no berries. Much damage was being done to the buds, but most of it without any doubt by *Lygus*, which was also abundant. It is, however, possible that *Antestia* may have contributed to the damage.

(b) *Damage to the developing berry.*

Gowdey (*loc. cit.*) stated that "by sucking the berries—the newly set as well as the well-developed berries—it causes them to drop." Anderson (*loc. cit.*) also believed that berry-fall is caused "especially when the stalks have been attacked." Ritchie (1929) has recorded serious berry-fall thought to be caused by *Antestia* and accentuated by dry weather. Hargreaves (*loc. cit.*) makes no mention of berry-fall. I have often seen nymphs, especially of the second and third instars, apparently feeding on the pedicel of a berry, but I have no proof that berry-fall is thereby caused.

It is generally agreed by all the authorities I have quoted that the principal damage to the developing berry is caused by the bug sucking the endosperm. This results in the bean becoming spotted and pitted and, if the attack has been severe, small and shrivelled. I have stated in Section 3 that *Antestia* is, at least at Amani, quite capable of sucking the beans contained in berries of which the parchment (endocarp) is hard and the bean (endosperm) semi-solid. Such beans, when fed on, become discoloured just as the younger beans do. If a large number of bugs feed on a young berry, the endosperm is sucked practically dry within 24 hours.

(c) *The transmission of Nematospora spp.*

The damage done to the bean is greatly intensified when *Antestia* introduces one or both of two species of the fungus *Nematospora*. Wallace (1930, 1931) proved experimentally that *N. coryli* Pegl. was carried by *A. lineaticollis*. He has recorded that on one plantation in the Moshi district as many as 295 out of 300 berries were attacked. Subsequently (1932, 1932a) he found that another species, *N. gossypii* Ashby and Nowell, was equally destructive, and that at Moshi both species occurred together. He also recorded *N. coryli* from Kenya and Uganda.

Probably one or both species are widespread wherever *Antestia* is found. They are not, however, universally present, or at least not at all seasons of the year, for I have examined berries from a plantation near Lyamungu on which *Antestia* was abundant, and though many of the beans showed signs of having been fed on, very few had internal bean rot.

Nematospora can be transmitted by nymphal as well as by adult *Antestia*. Besides *A. lineaticollis*, *A. faceta* and *A. trivialis* certainly, and I suspect also the other species, are vectors.

Infected beans rot very quickly; two days after a bug has first introduced the fungus a considerable part will be brown, a few days later the whole bean

becomes rotten and stinking, and subsequently it shrivels. Infected beans are not only valueless in themselves, but may taint sound ones.

(d) *Damage to the foliage.*

Anderson (1919) stated that "sometimes when the terminal buds are punctured the shoots die back for some distance. This might mean that not only does the bug pierce but at the same time injects something into the puncture." There are, however, no indications that the saliva of *Antestia* is toxic to plants, like the saliva of some CAPSIDAE (Smith, 1920), and fungi of the genus *Nematospora* can, so far as is known, only become established in seeds and fruits (Ashby and Nowell, 1926). Dieback is not mentioned by either Gowdey, Wilkinson or Hargreaves.

All these authorities are agreed that attack by *Antestia* near the growing point of young shoots results in the production of numerous secondary and tertiary branches. Thus Wilkinson (1924) wrote: "Bug attack on the young shoots results in the production of masses of leaves and branches with short internodes until the whole bush may present a matted appearance. These matted branches seldom, if ever, bear fruit until thoroughly pruned, or cut back, and naturally the pruning of such trees becomes increasingly difficult. Although this has not been experimentally produced, it is a phenomenon observed on most estates where *Antestia* is present as a pest and in the opinion of the writer it is the result of *Antestia* attack. At the same time it appears to be a characteristic of not a few coffee bushes in Uganda to present a similar matted appearance after the rains and before pruning has been done. This characteristic was not observed by the writer in Kenya. About the only reliable difference which could be pointed out as distinctive is the broader and more flattened appearance, dorso-ventrally, of the nodes in the case of bushes suffering from bug attack. This broad, flat, character of the nodes has already been observed by many planters and, I think rightly, put down to *Antestia*."

Smee (1931) has recorded *A. variegata* Thunb. [? = *faceta* Germ.] as producing in certain districts of Nyasaland "a very pronounced vegetative growth and a complete absence of crop. . . . The shoots were marked by abnormally short internodes . . . and a proliferated growth of secondaries or tertiaries from each node. . . . By caging specimens of the insects on apparently healthy coffee trees proof was obtained that [*Antestia*] was alone responsible."

I myself have failed to produce this condition experimentally, although I have kept very large numbers of *Antestia* for several months on a small coffee bush enclosed in mosquito netting. However, in order to keep them alive and stimulate breeding, branches bearing green berries were enclosed in the cage, and it is quite likely that the bugs fed scarcely at all on the growing plant. I have also seen coffee plantations, in both the Kiambu and Moshi districts, where although *Antestia* was exceedingly abundant this matted appearance of the branches was absent. I think, however, that the condition is produced by *Antestia*, but probably not unless the plantation has at some time of the year been almost devoid of berries, so that the bugs have been compelled to feed on the leaves and young shoots. It would be very desirable to obtain, if possible, further experimental proof of the connection of *Antestia* with this "witches' broom" appearance, which on some plantations is undoubtedly responsible for a large reduction in the crop.

(e) *Summary.*

Summarising my own opinions on the injuries caused by *Antestia*, the principal damage is due to the bugs sucking the developing berry and producing spotted and pitted beans. The younger the berries attacked, the greater is the harm done. If *Nematospora* is introduced, the bean is completely destroyed. In the absence of berries the young shoots are attacked, and a mat of short secondary and tertiary branches, which bear no crop, may be the result. The conditions under which this form of damage is produced require further study.

//(5) ECO-CLIMATIC FACTORS AFFECTING ABUNDANCE.

In East Africa arabica coffee is grown at all altitudes between about 3000 ft. and 7000 ft., and, therefore, under widely varying climatic conditions. Yet in most districts *Antestia* is, or at times has been, abundant.

I have shown (Kirkpatrick, 1935) that there are several distinct eco-climates in different parts of a single coffee bush. *Antestia* is a mobile insect, and therefore at liberty to choose that part of the bush in which it finds the most suitable conditions. That it actually does so, at least to some extent, I have observed on many occasions. Thus it is very seldom that *Antestia* can be found on exposed parts of unshaded bushes either in the middle of sunny days, when the outer parts of the bush are warmer than the interior, or on clear nights when they are colder. On the other hand, in the early morning and evening, and on cool cloudy days even at midday, they can often be seen on the surface of the bush, exposed to such radiant heat as there is. To some extent the presence of suitable berry-food must determine the part of the bush they frequent. I have, however, shown, at least in the laboratory, that they spend less than half the day sitting on their food (Table 9 in Section 3), and therefore probably a still shorter time actually feeding.

Consequently at first sight it seems that eco-climatic factors can have but little influence on the incidence of *Antestia*; this also appears to be supported by the apparently contrary opinions that have been expressed about the effect of shade. Thus Anderson (1925) considered that less damage was done to properly shaded coffee. Hargreaves (1924) gave it as his tentative opinion that absence of shade increased the numbers of the bugs and the damage done by them. Wilkinson (1924a) also said that "*Antestia* even when present in large numbers appears to cause little damage under shade."

On the other hand, Hargreaves (1929), referring to Toro, a different district of Uganda from that where his previous observations were made, wrote: "In most cases shade was probably responsible for the attack; with the removal of shade trees the pest disappeared . . . probably as a direct result of removal of protection of the bug from the effects of cold nights which are normally experienced in Toro."

I believe that shade may have the same effect in low-lying and hot districts. On a plantation near Moshi, at the lower limit of coffee cultivation (about 3500 ft.), I have found the bug much more common under shade than in an adjacent unshaded plot. I have, however, only made this observation at two seasons of the year (January and May) and only by visual estimation, not by the accurate method of spraying a number of trees, as recommended by LePelley (1934a).

I suggest that the foregoing observations, so far from being contradictory,

tend to show that in any one district eco-climatic factors exercise an appreciable influence on the abundance of *Antestia*. At higher altitudes, where the nights are in any case cold, it is more numerous in the less cold shaded plantations. If my own observations, which admittedly require confirmation, are correct, *Antestia* also requires the protection of shade at the other climatic extreme—at low altitudes where the day temperature is exceptionally high. In the intermediate districts it thrives best in unshaded plantations where the higher day temperatures probably have more effect in increasing the rate of reproduction than the higher night temperatures in shaded plantations.

Another important effect of shade is to raise the humidity of the air by day and to lower it slightly at night, and also to decrease considerably the deposition of dew (Kirkpatrick, *loc. cit.*). Wilkinson (1924) has adduced some evidence that *Antestia* tends to increase during a period of dry weather. Hargreaves (1930) has observed that "continuous clean weeding of the soil renders the coffee more liable to attack by *Antestia*." I have shown (*loc. cit.*) that weeds or a cover crop increase the humidity of the air. Much of the beneficial effect of shade (as of cover crops) may therefore be due to the higher humidity by day, and quite possibly to the less frequent deposition of dew at night. For even though *Antestia* thrives well in a dry atmosphere there is evidence (discussed in Section 3) that it then requires moisture to drink. Again, I have in Section 3 put forward the hypothesis that in a drier atmosphere *Antestia* prefers to feed on young juicy berries, and under damp conditions on the more mature ones. The younger the berries fed on, the more damage is done; this would therefore account for the statements quoted above that, even when the bug is abundant, it does less damage under shade.

(Anderson (1918) quoted a statement that more damage was done close to a *Grevillea* wind-break. Trench (1926) also wrote: "It has been observed that where wind-breaks have been allowed to get too thick or dense, that the outbreak of insect pests, such as *Antestia* and *Thrips*, are most prevalent."

A possible explanation might be the slightly higher day temperature caused by wind-breaks. I think, however, that it is more likely to be due to the competition of the *Grevillea* accentuating drought conditions. Trench (*loc. cit.*) has stated that "during long spells of dry weather, the coffee bushes have suffered from lack of moisture, due to the *Grevillea robusta* taking more than its share.")

I should expect that *Antestia* would tend to multiply less rapidly in bushes that are kept well pruned than in ones that have abundant thick foliage, because in the former the day temperature will be rather lower and the evaporation-rate higher. For the reasons already given this would probably not apply to low-lying hot districts nor to cold exposed plantations at high altitudes. Bushes grown on the multiple-stem system would be subject to conditions similar to those of fairly well-pruned single-stem bushes.

I believe, however, that the direct influence of climate is of minor importance compared with its indirect effect through the host plant. It is certain (Section 3) that *Antestia* reproduces most rapidly when green berries are available as food, though in some districts very young berries and in others older ones may be the more suitable. Consequently the *Antestia* population is most likely to remain at a high level where the climate (and the system of pruning adopted) favours several flowerings during the year. Drought conditions may in themselves increase the population and further, as suggested by Ritchie (1929), it is very probable that more damage is done to the crop on bushes suffering from lack of moisture. ")

(6) NATURAL ENEMIES.

(a) Hymenoptera. Egg-parasites.

Two species of SCELIONIDAE, *Microphanurus seychellensis* Kieff., until recently known as *Telenomus truncativentris* Dodd (Nixon, 1935), and *Hadronotus antestiae* Dodd (1919) are found in almost all districts in East Africa where *Antestia lineaticollis* occurs. In Nyasaland only the former species has been recorded (Smee, 1930).

Their life-histories have been described by Anderson (1919) and Dry (1921) and need not be repeated in detail here.

One or both of these parasites is usually abundant. Dry (*loc. cit.*) found that at Kabete in Kenya they were about equally common; the percentage of eggs parasitised by one or the other varied from 54 to 90 with an average of 77. Wilkinson (1924) recorded 95% parasitised in one district of Uganda and 40% in another; *Hadronotus* was the more numerous. No actual counts of the percentage of parasitism appear to have been made elsewhere, but Ritchie (1932) stated that in Tanganyika both species are "universally present but alone effect a control which permits of too great depreciation of crop."

Anderson (1936) recorded both species from the eggs of *A. faceta* in Uganda; though it appears not to have been observed, I think it probable that they would also attack other species of the genus.

Dry (*loc. cit.*) found that *Hadronotus* was the more prolific; the average number of offspring produced by each female was 51 when fed and 23 when unfed. *Microphanurus* averaged 22 and 7.5 respectively. The life-cycle, from egg to adult, of *Microphanurus* was shorter than that of *Hadronotus*, especially in cool weather. The variation recorded was: for *Microphanurus*, 21 days in February (average temperature 19.2° C.) to 46 days in July and August (average temperature 15.2° C.); for *Hadronotus*, 24 days in February to 62 days in July and August.

This may indicate that under warm conditions *Hadronotus* is likely to be the more abundant species.

Another species of *Microphanurus*, *M. suranus* Nixon, may also be an egg-parasite of *Antestia* in Uganda. Nixon (1936) described this species from three females bred by Gowdey in 1916 "presumably from hemipterous eggs; these females were evidently bred with a series of *Microphanurus seychellensis* Kieff.;" and from a pair bred by Hargreaves in 1929 "from hemipterous eggs on coffee."

Two varieties of the Eupelmid, *Anastatus bifasciatus* Fonsc. have been bred from the eggs of *A. lineaticollis* in Uganda by G. L. R. Hancock. These have been named by Ferrière (1930) var. *antestiae* and var. *hancocki*. There appears to be no experimental proof that they are not hyperparasites, but most species of this genus are primary parasites.

Species of three other genera, *Aprostocetus* (CHALCIDIDAE), *Baryconus* (SCELIONIDAE), and *Pleurotropis* (EULOPHIDAE), have been bred from eggs of *A. lineaticollis* in Uganda, the two former by Hancock (1926) and the third by Hargreaves (1927). It is presumed that these species are hyperparasites, for the latter author states that attempts to parasitise *Antestia* eggs with any species except *Telenomus [seychellensis]* and *Hadronotus antestiae* were unsuccessful.

(b) *Hymenoptera. Parasites on the nymphs.**Helorimorpha coffeae* Brues (BRACONIDAE).

This species was described by Brues (1924) from specimens collected in Kenya. It was then thought to be parasitic on a fruit-fly, but it has since been bred by LePelley in Kenya from both nymphs and adults of *A. lineaticollis* (Wilkinson, *in litt.*, 1936).

In July 1936 Mr. B. Cooper brought to Amani a number of immature *Antestia* collected in the Marangu district, on the south-east slope of Kilimanjaro.

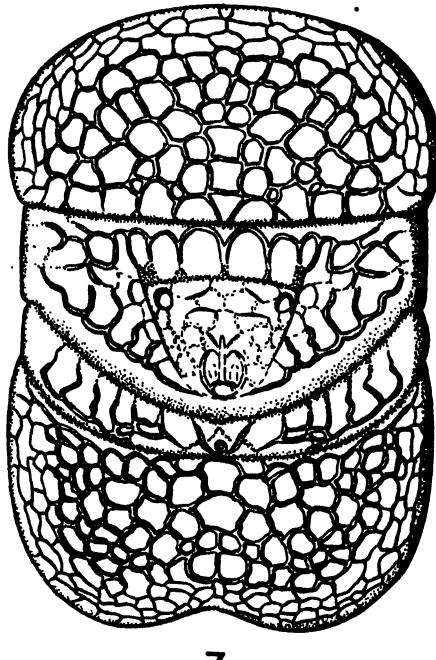
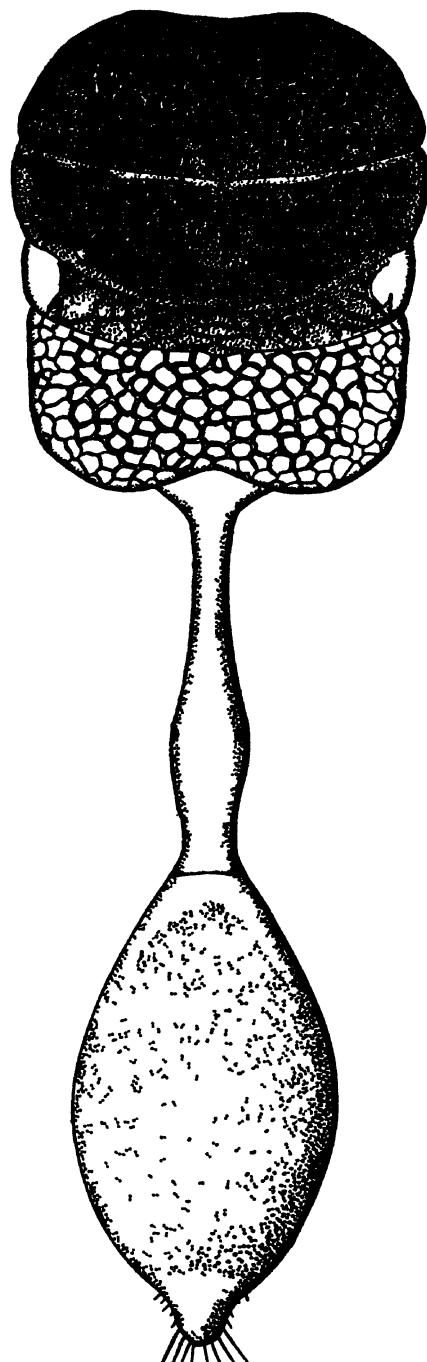


FIG. 7.—*Helorimorpha coffeae*. Thorax and propodeum. $\times 57$.

Several larvae emerged from these, but only three adults were obtained. Mr. H. Wilkinson kindly compared these with his named specimens of *H. coffeae* and confirmed my identifications. Since it appears not to have been figured, I give a drawing of the thorax and propodeum (fig. 7), for comparison with that of the next species. Unfortunately the only female I obtained died almost immediately, so I was unable to breed this species in the laboratory.

Helorimorpha ? sp.

From some nymphs of *A. lineaticollis*, collected in August 1936 on a plantation near Lyamungu, I obtained several larvae which were successfully bred to adult. Pending identification by the Imperial Institute of Entomology, I assign these provisionally to the genus *Helorimorpha*. The adult is 4.0 mm. in length, thus slightly smaller than *H. coffeae*, from which it is easily distinguished by the greater part of the dorsum of the thorax (but not the propodeum), and the sternum between the front and middle coxae, being almost black. The



8

FIG. 8.—*Helormorpha* sp. Thorax and abdomen. $\times 52$.

areolation of the thorax and propodeum (fig. 8) is very similar to that of *H. coffeeae* (fig. 7); the wing venation (fig. 9) is almost identical in the two species. I have found this species easy to breed in the laboratory; the following preliminary notes on its life-history may be of interest.

Oviposition. The female prefers to oviposit in second and third-instar nymphs. It will oviposit in first-instar nymphs, but apparently these then die prematurely; also in fourth-instar nymphs, if no others are available. I have watched it attempt to lay eggs in nymphs of the fifth instar, but it never succeeded, except in one that had just moulted and was still soft. It has also oviposited in an *Antestia* that had just moulted to the adult instar, but it will not even attempt to lay eggs in adults of which the integument has hardened. The female usually approaches from behind and feels the dorsum of the nymph

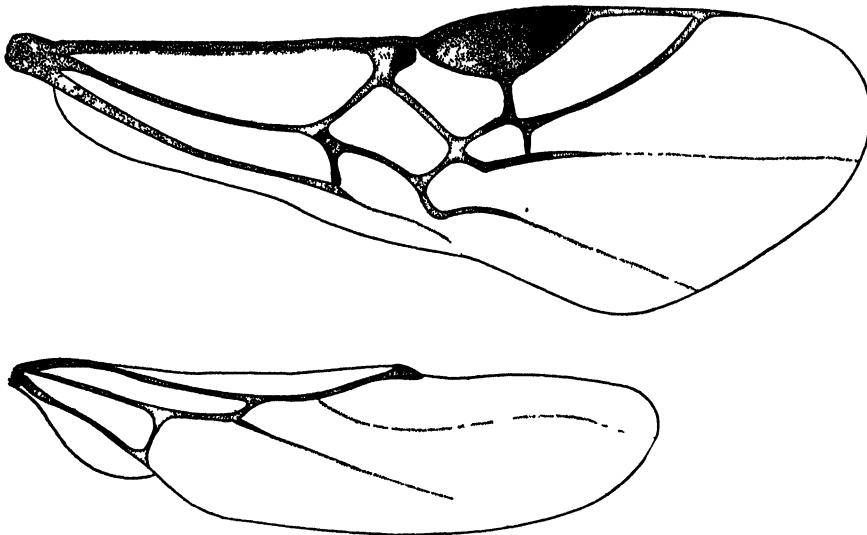


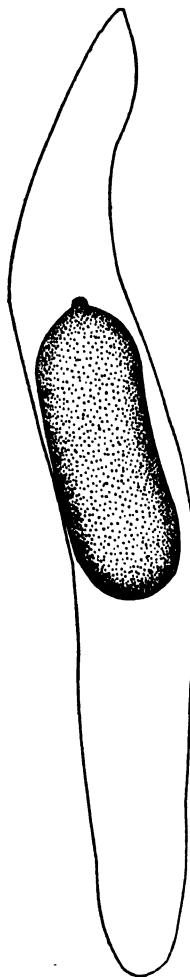
FIG. 9.—*Helorimorpha* sp. Wings. $\times 46$.

with its antennae. It then quickly bends its abdomen forwards under the thorax and between the legs, and stings the nymph near the base of the dorsum of its abdomen. Occasionally I have watched one sting a nymph in the venter of its abdomen. The ovipositor is usually withdrawn immediately. Sometimes a female fails to sting at the first attempt; it then usually tries again at once. But even an apparently successful attempt does not always result in the deposition of an egg. Of 145 nymphs which appeared to have been properly stung, only 110, or about 75%, produced larvae. Not all the remaining 35 were examined, but in those that were, I failed to find an unhatched egg.

If plenty of potential hosts are available a female will not usually lay more than one egg in each. I have, however, found as many as six eggs in one *Antestia*, laid by a female to which no other nymphs had been offered for several days. A female will also readily lay a second egg in a nymph that has moulted since it was first stung. But I have never found that more than one egg in each host hatched.

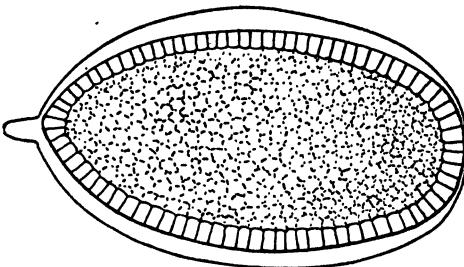
I have not ascertained the number of eggs that a female is capable of laying,

but I have watched one sting 25 nymphs within about 30 minutes; it would not then sting any more on that day. I have kept a fertilised female that continued to lay eggs, whenever potential hosts were offered to it, over a period of 28 days.



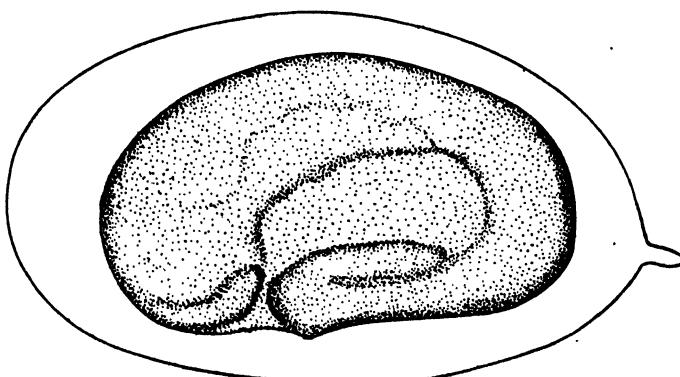
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FIG. 10.—*Helorimorpha* sp. Egg, 10 minutes after being laid. $\times 253$.



11

FIG. 11.—*Helorimorpha* sp. Egg, 24 hours after being laid. $\times 253$.



12

FIG. 12.—*Helorimorpha* sp. Egg, 48 hours after being laid. $\times 253$.

The chorion of the egg immediately after it has been laid is elongate and curved (fig. 10). A few hours later it has become oval and the embryo has swollen considerably (figs. 11 and 12). Under laboratory conditions, at a temperature ranging between 21° and 26°, the egg usually hatches 72–80 hours after oviposition.

Larva. The primary larva (fig. 13) is of the typical caudate form. Owing

to the wide variation in the time of development from oviposition to emergence of the mature larva (Table 11), I cannot say at what period the tail is lost and

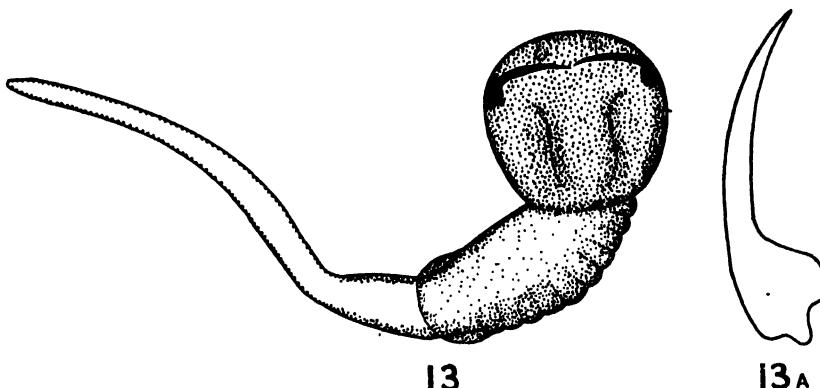


FIG. 13.—*Helorimorpha* sp. First-instar larva, shortly after hatching. $\times 103$.

FIG. 13a.—*Helorimorpha* sp. First-instar larva, mandible. $\times 410$.

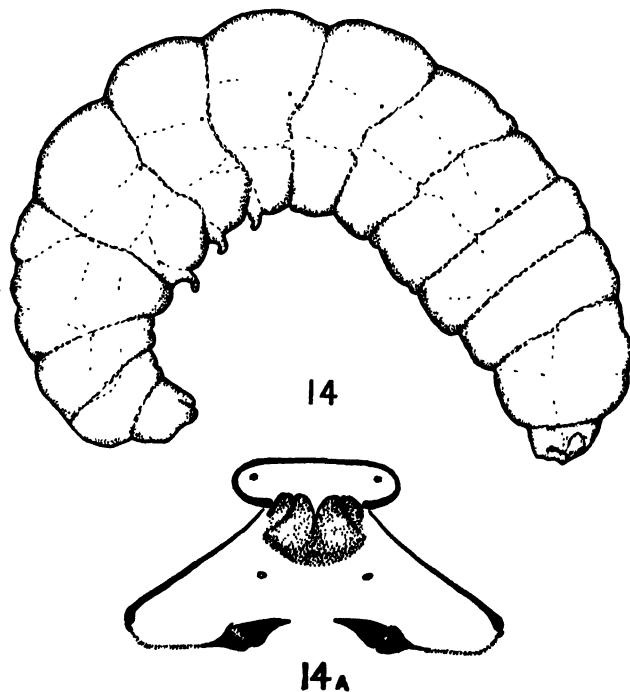


FIG. 14.—*Helorimorpha* sp. Mature larva. $\times 22$.

FIG. 14a.—*Helorimorpha* sp. Mature larva, mouth-parts. $\times 96$.

the maggot-like instar assumed. Larvae that I have examined twelve days after oviposition were still caudate and with the anal vesicle larger than in the newly-hatched larva. The mature larva (fig. 14) is white, entirely covered with very

short fine hairs; on the venter of each of the fourth, fifth and sixth abdominal segments there is a short unpaired process.

The larva leaves its host through a hole made in the abdomen, either on the dorsal or ventral surface and usually near the anus, but not through the anal aperture. The host generally dies between one and six days after the larva has emerged; a few have lived as long as nine days.

The period of development, from oviposition to the emergence of the mature larva, varies greatly even among larvae from eggs laid by the same female on one day, and in hosts kept under identical conditions. Table 11 shows the duration of this period, in days, for 333 larvae the hosts of which were kept in the laboratory at a temperature varying from a minimum of 20°-22° to a maximum of 25°-27°. Since I have occasionally found an unhatched egg in a host about two weeks after it had been stung, it may be that delayed development is due to some eggs not hatching in the usual time of about three days.

TABLE 11.

The period of development of *Helorimorpha* sp., from deposition of egg to emergence of mature larva from host.

Days . .	16	17	18	19	20	21	22	23	24	25	26
Instances . .	3	9	11	17	35	30	33	24	20	22	17
Days . .	27	28	29	30	31	32	33	34	35	36	37
Instances . .	16	14	12	11	9	12	9	6	2	3	2
Days . .	38	39	40	41	42	44	54	56	65		
Instances . .	3	2	2	1	2	1	1	1	1		

A parasitised nymph will undergo one, and sometimes two, ecdyses before the larva emerges, but delayed development of the latter apparently entails prolongation of one of the host's stadia. This is not quite certain, for it has been shown in Section 2 that the stadia of *Antestia* are occasionally, for no apparent reason, prolonged for much more than their normal duration. I do not, however, think that such prolongation of the host's stadia is the cause of the frequent delayed development of the parasite, as shown in Table 11, for the proportion of hosts of which an ecdysis has been delayed, when they have been parasitised by *Helorimorpha* sp., is much in excess of that among unparasitised *Antestia*.

Pupation. The mature larvae usually leave their hosts early in the morning, most of them before 06h. and few later than 08h. They move quite fast, always backwards, and as a rule all the time emitting a thread of silk. If loose dry earth is available they quickly burrow into it and spin a cocoon. They will also spin on the floor of their cage or on coffee berries, but in the absence of earth many die, apparently through having wasted their silk in trying to spin up in an unsuitable place. Larvae that fail to spin a cocoon by about noon on the day they emerge apparently never survive, though they may not die for another day or so. The cocoon is oval, of tough very viscous white silk. The time elapsing from spinning a cocoon to the emergence of the adult is, under conditions of temperature mentioned above, 17-19 days for males and 20-21 days for females. I have kept the adults alive for as long as 40 days in the laboratory, feeding them on dextrose syrup.

Copulation. Both sexes will copulate almost immediately after emergence from the pupa. The male, continually fanning its wings, approaches the female from behind and thrusts its abdomen under its thorax in order to effect copulation—in just the same way that a female does in order to oviposit. Copulation lasts a few seconds only but may be repeated at frequent intervals

during the first day, and occasionally on the second day, that a pair are put together. After that a male appears to take no further interest in a fertilised female.

Proportion of sexes. The offspring of fertilised females are of both sexes, females being about twice as numerous as males. Unfertilised females readily oviposit but their offspring are all males, as is usual with parasitic Hymenoptera.

Hosts. This parasite will, in the laboratory, readily breed in *A. faceta* and *A. trivialis* as well as in *A. lineaticollis*.

I have offered them young nymphs of a few other species of PENTATOMIDAE. Some of these they attempted to sting, but I could find neither eggs nor larvae in any except the three species of *Antestia* mentioned.

Multiparasitism. I have only recorded, in the field, a single case of multi-parasitism, i.e. "the simultaneous infestation of the same individual host insect by two or more species of primary parasites" (Imms, 1931). This was a nymph of *A. lineaticollis*, from which a larva of *Helorimorpha* sp. emerged, and which, when it died a few days later, was found to contain two larvae of *Corioxenos*. Experimentally, in the laboratory, I have several times produced multiparasitism with *Helorimorpha* and *Corioxenos*. Whichever parasite entered the host first, the Hymenopteron was always the survivor.

(c) *Strepsiptera. Corioxenos antestiae Blair.*

I first found this species early in 1935, at Lyamungu near Moshi. The method of its discovery is of some interest. I was working on an eco-climatic problem for which large numbers of *Antestia* eggs were required. One morning I casually boxed the first specimen of *Antestia* I saw, in order to show it to my African assistant, so that he could collect the bugs for me. On returning to the laboratory I was surprised to see a living male Strepsipteron in the "pill-box." I did not at once connect the two, thinking that I had accidentally boxed the Strepsipteron without at the time seeing it. However, when the numerous *Antestia* collected by the "boy" laid scarcely any eggs, I examined a number of them and found that a large proportion was stylopised.

On the slopes of Kilimanjaro there are coffee plantations at all altitudes between about 3500 ft. and 6000 ft., and they are, therefore, subject to a wide range of climatic conditions. I found *Corioxenos* parasitising *Antestia* on all the plantations I visited, and also in the Arusha district, on the slopes of Mount Meru. It appears, however, to be restricted to these two mountains, for I have examined large numbers of *Antestia* from other districts in Tanganyika and also from Kenya (these kindly supplied by Mr. Notley) but never found a single one stylopised.

In view of the great interest of finding a Strepsipteron in a host so easily bred in captivity as *Antestia*, and moreover in a host of economic importance, it appeared worth while to devote some considerable time to a study of this parasite. The results of these investigations are given in detail in Parts II and III of this paper.

(d) *Diptera. Epineura rubens Villen. (TACHINIDAE).*

This was first recorded by Hargreaves (1925) from the Mitanya district of Uganda. Wilkinson (1924) stated that the percentage of *Antestia* parasitised by it was only 2½, and that from 41 larvae which left their hosts and pupated no more than six adults emerged. Larvae emerged only from adult bugs, but it is not known in what instar of the bug the egg is laid, since he was

unable to get the fly to oviposit in captivity. Wilkinson (in litt., 1936) has informed me that LePelley has bred this species from adult *A. lineaticollis* in Kenya. From several hundred adult *A. lineaticollis* collected in the West Usambaras, Tanganyika, I obtained three dipterous larvae. These pupated but adults failed to emerge, so I am unable to say whether they were of this species.

(e) *Acari.*

The larva of an Erythraeid mite is sometimes found attached to adult *Antestia*, usually on the underside of the fore-wings or under the scutellum. I have never found them common, except on one plantation in the West Usambaras, where over 50% of the *Antestia* (*lineaticollis*) collected had one or more mites adhering. Several had ten or more, and one as many as 40. The bugs with such large numbers appeared to be unhealthy and to die sooner than those with few or none. It is, however, possible that the mites attach themselves more readily to *Antestia* that are old or otherwise weakened, and I am very doubtful whether they are really ectoparasites. I was unable to breed the adult mite.

(f) *Protozoa.*

A flagellate Protozoan, possibly of the genus *Leptomonas*, is often found in the intestine of both nymphs and adults of *Antestia*. In many it is absent, but if present at all it is usually in enormous numbers. I have no evidence that it has any effect on its host.

(g) *Predators.*

Antestia, like all Pentatomids, is very seldom attacked by predators. Hargreaves (1930) stated that "Mantids of undetermined species have been observed to prey on the bug," and this is the only definite observation of an insect predator on record. According to Hargreaves (1936) "It seems likely that several species of carnivorous ants such as *Oecophylla smaragdina* and *Macromischoides aculeatus* . . . play some part in the control of *Antestia*." I have myself sometimes seen ants carrying off dead *Antestia*, but have never for certain observed them to attack living ones.

LePelley (1934) records that several planters in Kenya state that *Antestia* is controlled by birds. "Droves of blue starlings regularly clear up severe attacks leaving hardly an insect to be seen." This planter "is satisfied with the control by blue starlings and uses no other." LePelley's comment is that "he is to be envied."

I am informed by Mr. R. E. Moreau, who has an extensive knowledge of East African birds and their habits, that the "blue starlings" are typically frugivorous and would be unlikely to eat insects.

LePelley (*loc. cit.*) has himself observed that poultry will follow the sprayers and eat *Antestia* as they drop to the ground, but, as he remarks, "it is obvious that they cannot influence the position on a plantation."

(7) ARTIFICIAL CONTROL MEASURES.

Three distinct methods for the control of *Antestia* have been widely recommended: hand collection, contact insecticides, and poison bait sprays.

(a) *Hand collection.*

This method has, until recently, been advocated by almost everyone who has offered advice about the control of *Antestia*. It has found considerable favour among planters, who are impressed by the large numbers of bugs that can be killed without any capital expenditure or much supervision. Wilkinson (1924) recommended smoking the bushes with smouldering cow-dung as an aid to collection. This causes many of the bugs to run to the centre of the bush and down the trunk. There is no doubt that if hand collecting is to be practised at all, it should be done in conjunction with smoking.

Widely different estimates of the cost of hand collection have been given by different authors. Thus Hargreaves (1936) stated that the low cost, "about five shillings per acre per year," is one of its main advantages over other methods. On the other hand, LePelley (1934) wrote: "Of the total number of insects present on trees thick in foliage, the percentage collected at a cost of Sh. 136/- per acre was 80 per cent. The best experimental results obtained was a reduction of *Antestia* by 75 per cent. on trees which had been reduced by drastic pruning almost to a condition of leafless sticks. This cost Sh. 20/- per acre."

Recently LePelley (1935) has made an experimental study of this method on coffee plantations in Kenya. He has presented his evidence in detail and concludes that "in practice the cost of picking an adequate percentage is almost invariably prohibitive."

With this conclusion, as applied to large European-owned plantations, I am in full agreement. I think, however, that on small native holdings of perhaps two or three hundred bushes, which are carefully looked after by the owner himself, hand collection (which will be done, unpaid, by his family) may still be of economic value.

(b) *Contact insecticides.*

Various contact sprays were tried by Gowdey (1918) in Uganda, the most effective of which was a resin wash (caustic soda, 4 lbs.; resin, 6 lbs.; whale-oil soap, 10 lbs.; water 45 gallons). He also stated that a nicotine spray was effective but its cost prohibitive. Apart from this suggestion contact sprays have been neither advocated nor, so far as I know, employed, until the recent experiments in Kenya on the use of pyrethrum. This was first recommended by LePelley (1932) in the form of an extract of 1 lb. pyrethrum powder in 1 gallon paraffin, used undiluted with a small "mist" sprayer. It was originally tried, and proved to be efficacious, against the Capsid *Lygus simonyi* Reut. (= *L. coffeae* China); subsequently LePelley (1932b, 1933) stated that in many circumstances it was also the most satisfactory method of controlling *Antestia*. He recommended its use (1) when *Lygus* is also present; (2) when the infestation of *Antestia* is particularly severe; (3) when two or three sprayings with the poison bait (discussed below) have failed to effect control. He claimed that a 95% kill should be obtained by one application of this spray, if properly applied according to his directions. (It is almost essential to cover each bush with a sheet while it is being sprayed. Either the ground under the bushes must also be sprayed after the bugs have dropped, or children must be employed to pick up the fallen bugs. If neither procedure is adopted many of the bugs recover.)

The chief drawback of pyrethrum-paraffin sprays is the high cost, about Sh. 11/- to 16/- per acre for one application. Two sprayings will usually be necessary, at least if there are many eggs of *Antestia* on the bushes.

LePelley (1933) discusses the effect of this spray on the fauna of the coffee plantation. He admits that "a large proportion of the Coccinellid and other predators of *Pseudococcus lilacinus* [= *P. kenyae*] and other insects are killed. Where *Pseudococcus* [*kenyae*] is a major pest, and it is known that it is being controlled by predators, it is probably not advisable to use this spray." Many Hymenopterous parasites, e.g. of *Antestia* eggs or of leaf-miners (*Leucoptera* spp.), are also killed, but since only those present as adults at the moment of spraying will be destroyed, he does not consider their loss serious.

This method is of little use during wet or windy weather, or on plantations with multiple stem bushes, the tops of which are often out of reach of a small "mist" sprayer. For such conditions Notley (1933) recommends emulsifying the pyrethrum-paraffin extract with soap and diluting with water in the proportion of 1:50. About one quarter of a gallon* is required for each bush.

With a dilution of 1:150 the bugs will fall off the bush in a comatose state, but not be killed. Children must then be employed to collect them; provided that the plantation is free of weeds, this method is slightly cheaper.

Notley estimates the cost at about Shs. 14/- per acre using the stronger concentration and Shs. 10/- with the weaker followed by collection of the fallen bugs, as compared with Shs. 16/- for the undiluted pyrethrum-paraffin extract.

Dusting with pyrethrum powder appears first to have been tried by Ritchie (1932), who stated that he obtained 100% kill but that the physical properties of the powder were unsatisfactory, and there was much wastage from pelleting.

Recently, however, Notley (1936) has recommended dusting with very finely ground pyrethrum powder. An application of 8 lbs. per acre resulted in a kill of 94.2% of *Antestia* (and 95.6% of *Lygus*). The cost is given as Shs. 5.50 per acre, or less than half that of the other methods involving the use of pyrethrum.

(c) Poison bait sprays.

Control of Hemiptera by means of stomach poisons is unusual, but several attempts have been made to find an efficient poison bait for *Antestia*, one of which has met with considerable success.

Anderson (1919) tried many varieties of poison baits, in most of which the toxic principle was apparently Paris Green, but the results were not promising. In 1923, Ritchie began experiments with sweetened sodium arsenite. Eventually (Ritchie, 1932) the following formula was recommended—arsenite of soda, 60 grammes; unrefined sugar, 5 lbs.; water, 4 gallons. A minimum dose of one fluid ounce is applied to each bush with a sprayer that gives an upwardly directed fine mist. Three or more sprayings may be necessary, but the cost of each is small, and Ritchie states that "Antestia control by this method should cost from 5 to 6 shillings per acre per annum." In the coffee plantations of the Moshi and Arusha districts of Tanganyika bait spraying has become the standard method of control, and at least the majority of planters are completely satisfied with it. It has, however, not met with the same success in Kenya and Uganda. LePelley (1932a) has studied the reason for this in Kenya. He made a careful estimate of the effect of poison bait

* LePelley (1934) questioned this and said that "Experience in the Kiambu district has shown that a minimum of about 1 gallon a tree is necessary with water sprays used as insecticides."

on the fauna of a coffee plantation, and concluded that the resulting destruction of the egg-parasites of *Antestia* might be the cause of some of the unsuccessful results. I have advanced the suggestion (Section 8 (c); see also Part II, Section 3 (e)) that the almost consistently good results claimed for poison baiting in the Moshi district may be explained by the fact that there the control effected in other districts by Hymenopterous egg parasites is largely replaced by the Strepsipteron *Corioxenos*.

Apart from the frequent failure of poison bait to control *Antestia* in Kenya, LePelley (*loc. cit.*) has suggested that it resulted in an increase in the numbers of injurious COCCIDAE and of leaf-miner (*Leucoptera* spp.), owing to the destruction of their natural enemies. Later (1934) he obtained further evidence that there was a real danger of serious outbreaks of leaf-miner following on repeated sprayings. Hymenopterous parasites readily feed on the sweetened bait, which will remain strong enough to kill them for some time after it has become diluted by rain and dew below the strength necessary to kill *Antestia*. Hargreaves also reported (1932) that in Uganda arsenic bait spray "in one instance resulted in severe attack by mealy-bug, presumably by poisoning its natural enemies."

(8) THE CONTROL OF *ANTESTIA*. SUMMARY.

(a) *Eco-climatic and cultural methods.*

Although it is very unlikely that complete control can anywhere be obtained solely by eco-climatic or cultural methods, I suggest that the following should tend to reduce the population of *Antestia*.

(1) The presence of canopy shade, which will raise the humidity of the air by day, decrease the dew-fall, lower the day temperature, and conserve soil-moisture. But in districts where cool and damp conditions both of the air and of the soil are prevalent, these results may have little effect and may be offset by the raising of the night temperature, which in an unshaded plantation would be too low for *Antestia*. Similarly in hot dry low-lying districts shade may render the conditions more suitable for the bug by reducing the high day temperatures.

(2) Avoidance of clean weeding or, preferably, growing a cover crop. This will raise the humidity of the air, lower the night temperature, and conserve soil moisture. It is most likely to be advantageous where shade is for some reason undesirable or impracticable.

(3) Absence of wind-breaks, except where they are really necessary as a protection from high winds. Certain trees commonly used, e.g. *Grevillea*, take more moisture from the soil than they conserve by reducing evaporation, and should therefore be dispensed with, if possible, in districts liable to drought.

(4) Adopting a system of pruning that reduces "intermittent flowering" to a minimum, so that as far as possible all the crop on the bushes at any one time is in about the same stage of development. The influence of pruning at different times of the year on the time of flowering is at present being investigated in Kenya (Trench, 1936). //

(b) *Biological control.*

There can be no doubt that the Hymenopterous egg-parasites and, where it occurs, the Strepsipteron *Corioxenos*, are of the greatest importance in reducing the rate of increase of *Antestia*.

I am very doubtful if any of the other recorded parasites are of much

value; possibly the species of *Helorimorpha* may at times exercise some influence in certain districts.

It has often been suggested (Anderson, 1919; Wilkinson, 1924; Hargreaves, 1930; LePelley, 1932a) that in order to increase the population of egg-parasites the eggs of *Antestia* should be collected, kept in suitable cages, and the emerging parasites liberated in the plantation. Theoretically this sounds an excellent recommendation, but in practice the number of egg-batches that can be collected by even the most careful searchers is a very small proportion of those present. A little carelessness in the conditions under which the collected eggs are kept, or neglect to liberate the adult parasites immediately they emerge, may well result in more harm than good being done. LePelley (1934) himself said of this procedure that it "may be completely excluded from further consideration by planters; it is valueless."

I believe that the only practical way of aiding the biological control of *Antestia* is by the choice of the most suitable method of artificial control, according to whether most of the biological control is being effected by egg-parasites or by *Corioxenos*. This is discussed below.

(c) *Artificial control.*

It has been seen that except possibly in small native holdings, hand collection as a means of control may be ruled out. There remain what can almost be described as the two rival methods—baiting with sweetened arsenic and, in some form or other, spraying or dusting with pyrethrum.

I suggest that where most of the natural control is due to *Corioxenos*, sweetened arsenic bait is, quite apart from its relative cheapness, the preferable method. For it will not kill the triungulins of *Corioxenos* that are waiting on a coffee bush until they can find a host, since they do not feed; though it will of course kill adult *Antestia* that may contain parturient female parasites, these will, while dying, continue to produce unharmed triungulins. Pyrethrum would probably destroy most of the free-living triungulins on a bush and, since it is much quicker in its action than poison bait, it is unlikely that many triungulins would escape from parturient hosts killed by it.

Where *Corioxenos* is absent and the egg-parasites are the most important natural controlling factor, pyrethrum would appear to be the more advantageous, since it destroys a smaller proportion of the egg-parasites than poison bait does.

PART II.

THE BIONOMICS OF *CORIOXENOS ANTESTIAE*.

(1) DESCRIPTIONS OF THE INSTARS.

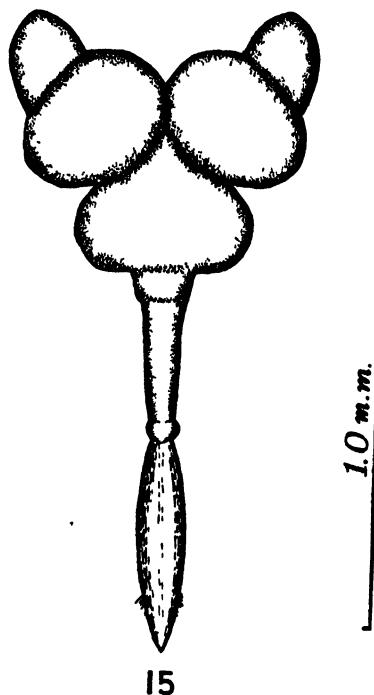
Shortly after this Strepsipteron was found specimens were sent to Sir Guy Marshall, Director of the Imperial Institute of Entomology, who passed them on to Dr. K. G. Blair for description. Blair's original description (1936) is of necessity incomplete in certain details, since he was dealing with preserved material. Moreover, at the time when the specimens were sent to him I had not succeeded in recognising all the larval instars. Indeed I cannot even now be quite certain that I have correctly determined the number of the stadia. Dyar's law is inapplicable to a larva with no sclerotised parts and subject to a

considerable increase in size during any one stadium. The exuviae are so delicate that it is difficult to find more than traces of them. In the case of most of the ecdyses I have had the fortune to dissect hosts containing larvae that had begun to moult. This is not so, however, for the ecdysis between what I have assumed to be the third and fourth parasitic instars; there is therefore no positive evidence that these are not actually a single instar. Moreover, from the beginning of the third to the end of the fourth parasitic stadium there is comparatively little change in form in either sex. But in view of the great increase in size during this period it seems more probable that two stadia are comprised.

The following can therefore be added to Blair's original description.

The adult male (fig. 36 (Blair's fig. 1)).

Predominant colour in life a dull dark brown, the dorsum of the thorax almost black, scarcely shining; the eyes jet black, shining; the abdomen almost



15

FIG. 15.—*C. antestiae*. Reproductive organs of adult male.

black beneath, greyish-brown on the dorsum during life but darkening at death; the intersegmental membranes greyish. Last tarsal segment pale brown. Wings smoky brown, the veins almost black. Length of body, excluding the antennae and the deflexed last abdominal segment, about 4.0 mm. during life, sometimes rather more when the abdomen is fully distended. At death the abdomen shrinks rapidly and considerably. Antennae 0.95 mm. long, the maxilla together with the palp 0.43 mm. Expanse across wings 5.5 to 6.0 mm.

Genitalia (fig. 15) simple, the testes globular with a smaller accessory lobe,

opening without a vas deferens into an unpaired heart-shaped vesicula seminalis. Aedeagus lanceolate, brownish-yellow, 0.4 mm. long, with about six minute forwardly directed bristles on each side towards the apex.

The adult female (fig. 16).

Blair has stated that the cephalothorax of the adult female is asymmetrical. While this is quite correct, it should be pointed out that the asymmetry is an acquired character depending on which side of the host extrusion occurs. Just before extrusion the cephalothorax is quite symmetrical. The cephalothorax of the female figured by Blair (his fig. 3) is one which had been exserted on the left side of the host. The outer side (in respect of the position in the host), *i.e.* the right-hand side of this figure, is always more regular and less indented than the inner side.

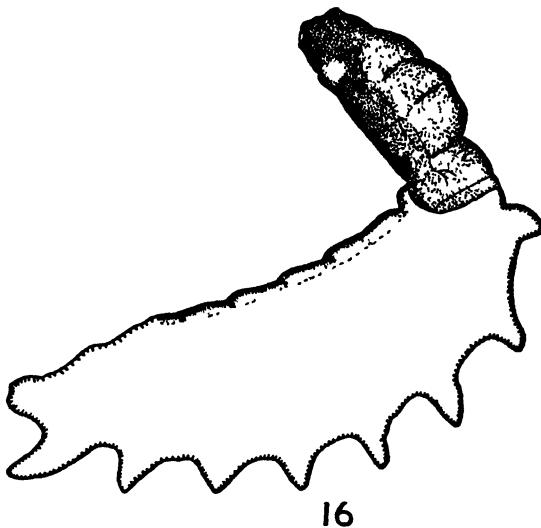


FIG. 16.—*C. antestiae.* Adult female, unfertilised.

Perhaps the most remarkable thing about the female of *Corioxenos*, which so far as I know has no parallel in the animal kingdom, is the fact that it has two genital openings, one on each side of the cephalothorax, through either of which fertilisation can be effected. The females of other species of Strepsiptera, of which the hosts are for the most part Hymenoptera and Homoptera, have a single median genital opening, but then the cephalothorax is exserted from the host's abdomen in such a position that the opening is readily visible by and accessible to the male (*vide* Perkins' (1918) figure of *Stylops aterrima* Newport in the act of copulating).

The exserted cephalothorax of *Corioxenos* is, on the contrary, usually quite concealed by the wings of the host and it is clear that, if there were a median genital opening, it could only be reached with difficulty, if at all, by the aedeagus of the male. They "must," therefore, have two openings, one on each side,

since it is pure chance on which side of the host extrusion will take place. Speculation on how such an adaptation has arisen must be left to evolutionists.

The abdomen of the adult female, as of the later larval instars of both sexes, has eight * backwardly projecting dorsal prominences. The function of these is, I think, mainly to increase the absorptive area of the body surface, but they also serve as locomotor organs. By rhythmical movements of the prominences the larva is able to move slightly within the body of the host and in this way is no doubt able to get into the correct position for extrusion. In the fertilised female (fig. 17) the abdomen swells so much that the prominences disappear.

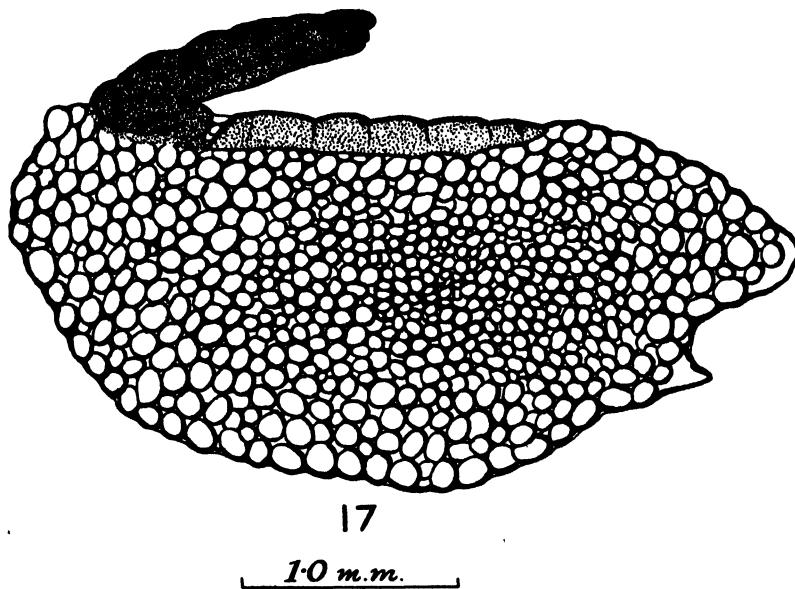


FIG. 17.—*C. antestiae*. Adult female, fertilised.

The first instar, or triungulin, larva (fig. 18).

In life the triungulin is shining black, from 0.25 to 0.27 mm. in length and about 0.10 mm. in breadth. The central pair of tail bristles is 0.11 mm. long; at 0.065 mm. from the base there is a swelling which is a reservoir for the sticky secretion from the glands in the apex of the abdomen (Cooper, 1937). The duct of this gland opens just beyond the reservoir; the terminal third of the bristles is exceedingly fine. The eyes are not readily visible in the living triungulin, but are easily seen in the nearly mature embryo (fig. 19). Having penetrated a host the triungulin swells considerably and the intersegmental membranes become visible. The method of ecdysis is described in Section 4.

The second (first parasitic) instar.

The first parasitic instar larva, shortly after it has left the exuviae of the triungulin, is somewhat scarabaeoid in shape, the anterior end being the stouter (fig. 20). When extended it is about 0.4 mm. in length, but it is usually slightly curved. Traces of the eyes of the previous free-living instar are just visible as a

* Blair's fig. 2, which shows only six dorsal prominences, is incorrect in this respect.

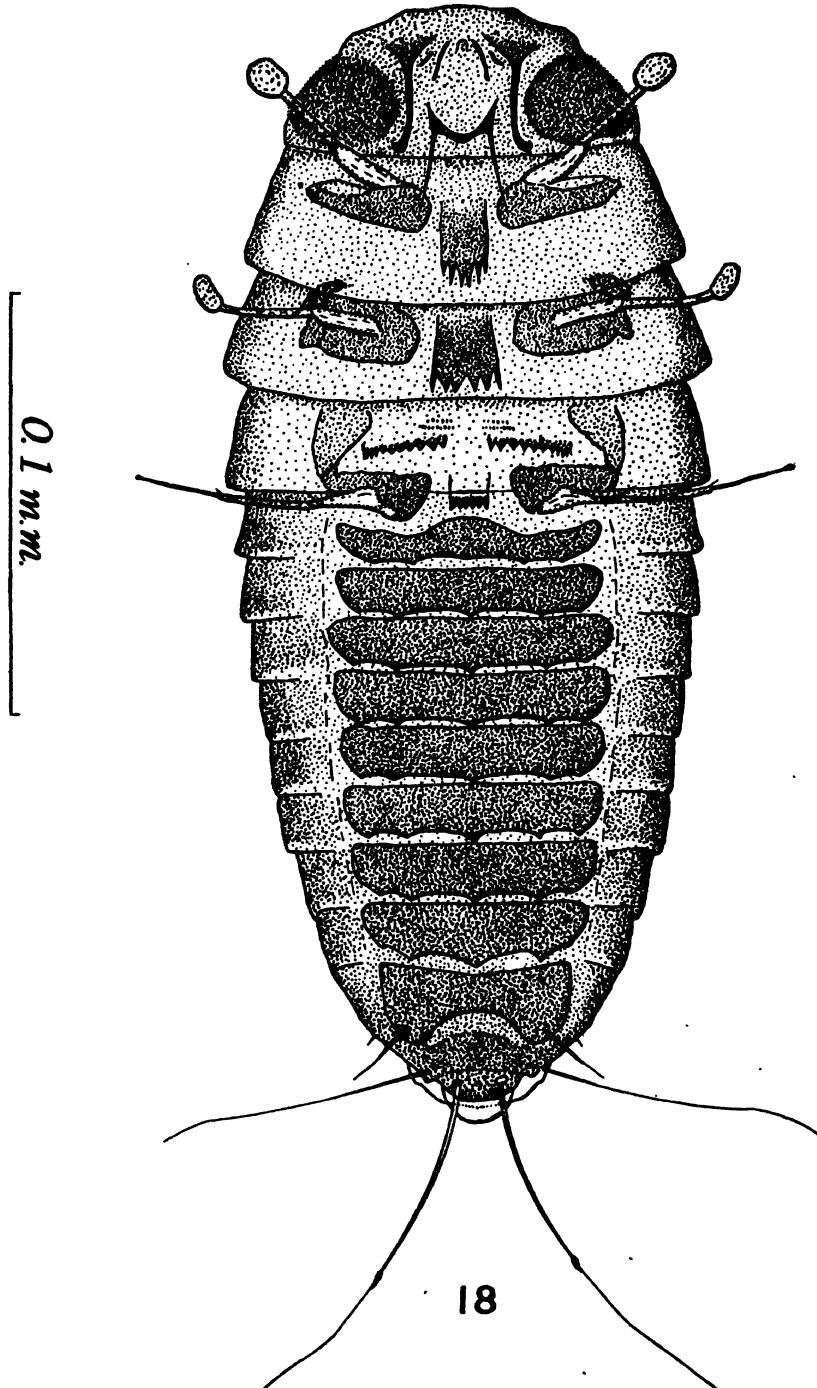
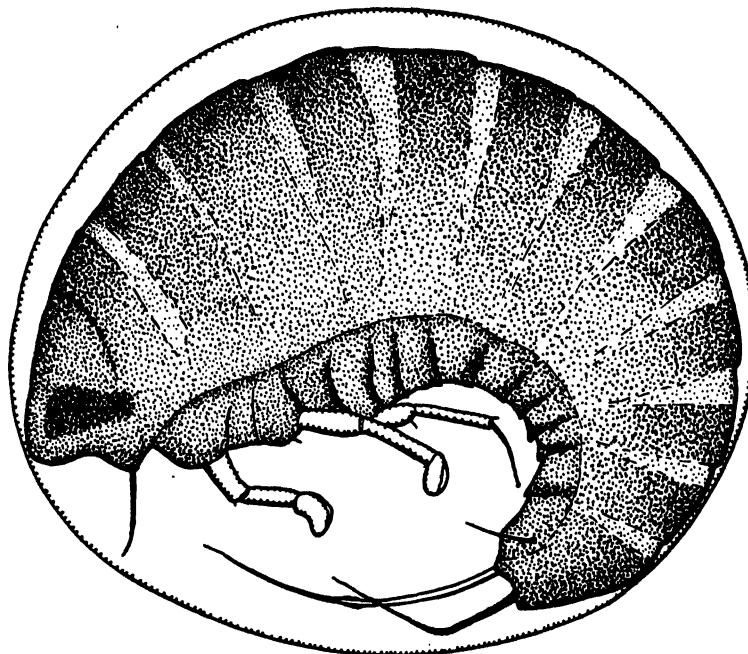


FIG. 18.—*U. antestiae*. Triungulin larva (ventral view).

pair of dark spots; three pairs of very inconspicuous protuberances represent all that remains of the legs of the triungulin. Segmentation is scarcely visible.



0.1 m.m.

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FIG. 19.—*C. antestiae*. Mature egg just before eclosion of triungulin.

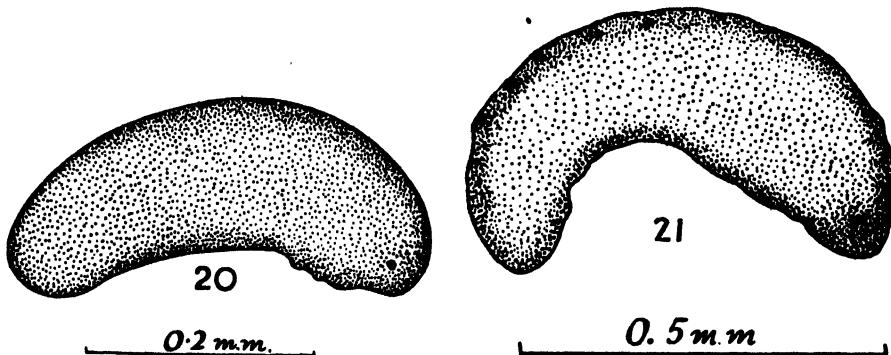


FIG. 20.—*C. antestiae*. First parasitic instar larva, at beginning of stadium.

FIG. 21.—*C. antestiae*. First parasitic instar larva, at end of stadium.

Towards the end of the stadium (fig. 21) the size has increased to about 0.6 mm., and the eye-spots tend to disappear.

Shortly before ecdisis the larva, which in fact has already developed to the next instar, shrinks slightly and becomes completely detached from its old skin

before this is actually shed. This also occurs before each subsequent ecdysis, so that a larva of one instar may often be seen completely within the integument of the previous instar (fig. 28). I have been unable to distinguish between the sexes of the first parasitic instar larvae.

The third (second parasitic) instar.

In both sexes this is about 1.1 to 1.4 mm.* in length, the male (fig. 22) being thicker in proportion than the female (fig. 23) and as a rule less curved. Segmen-

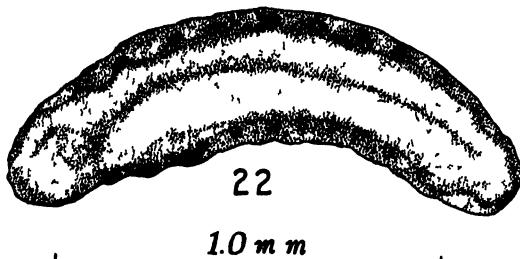


FIG. 22.—*C. antestiae*. Second parasitic instar larva, male.

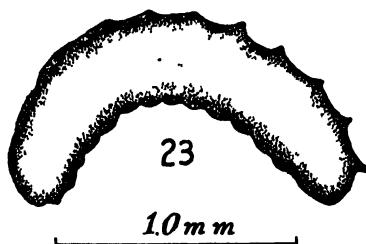


FIG. 23.—*C. antestiae*. Second parasitic instar larva, female.

tation, though still ill-defined, begins to be apparent. The male retains traces of the legs, but these are no longer seen in the female. In the female indications of the dorsal prominences are first visible. In the male these can, towards the end of the stadium, be detected under the skin, but they do not actually appear until the next instar.

The fourth (third parasitic) instar.

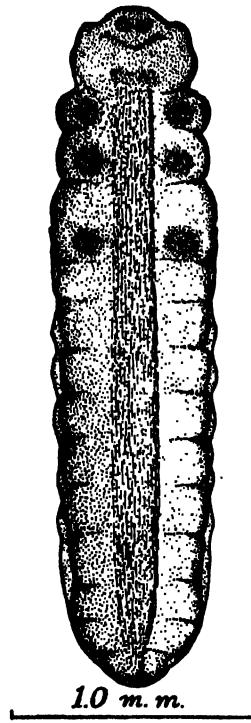
The male (fig. 24) is 2.7 to 2.8 mm. in length. The segments of the head, thorax and abdomen are now distinct and the leg rudiments are more conspicuous. Traces of the mouth-parts are just discernible. The female (fig. 25) is about the same length but more slender. The eight dorsal prominences are now well-marked.

The fifth (fourth parasitic) instar.

The male larva (fig. 26) is 3.6 to 3.7 mm. long, and the female (fig. 27) rather less. The dorsal prominences are now conspicuous in both sexes although

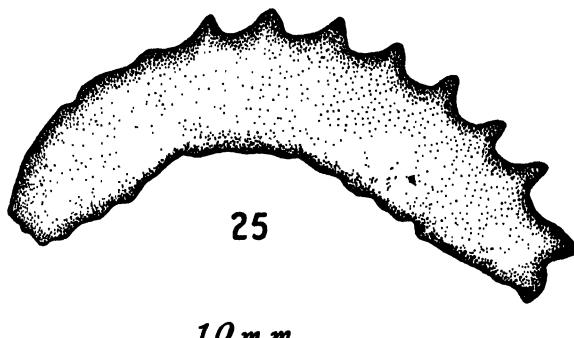
* These and subsequent measurements of the larvae are made from living specimens that were, so far as could be judged, at about the maximum size attained during the stadium.

those of the male are, as they are in later stages, much smaller than those of the female. Otherwise there is little apparent change from the previous instar.



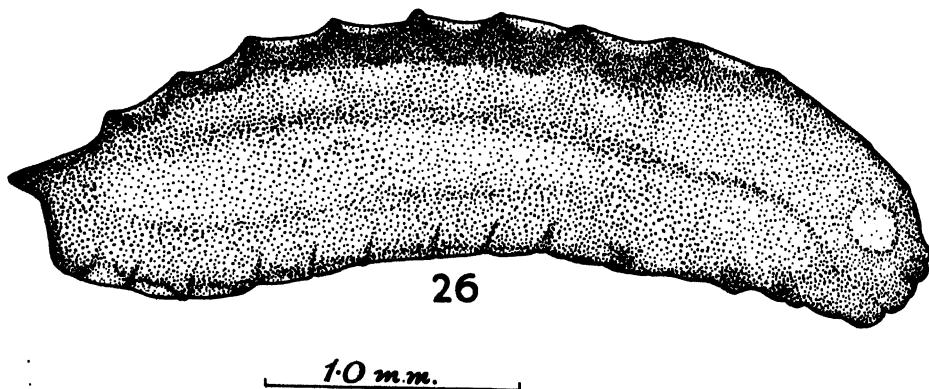
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FIG. 24.—*C. antestiae*.
Third parasitic instar larva, male.



25

FIG. 25.—*C. antestiae*. Third parasitic instar larva, female.



26

FIG. 26.—*C. antestiae*. Fourth parasitic instar larva, male.

The sixth (fifth parasitic) instar.

The male larva is about 4.0 mm. long. (Fig. 28 shows a male larva of this instar before it has shed the skin of the previous instar, and therefore before it

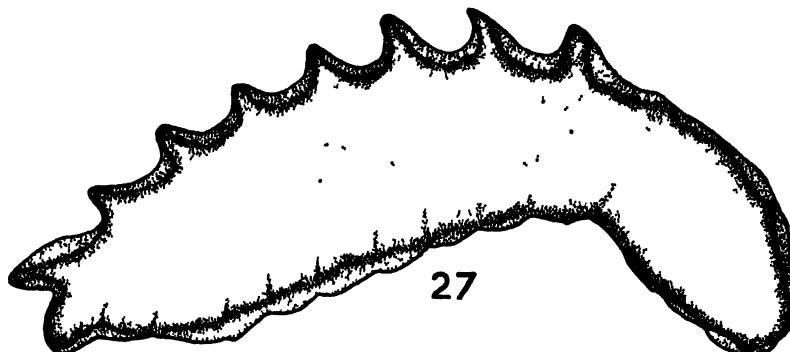


FIG. 27.—*C. antestiae*. Fourth parasitic instar larva, female.

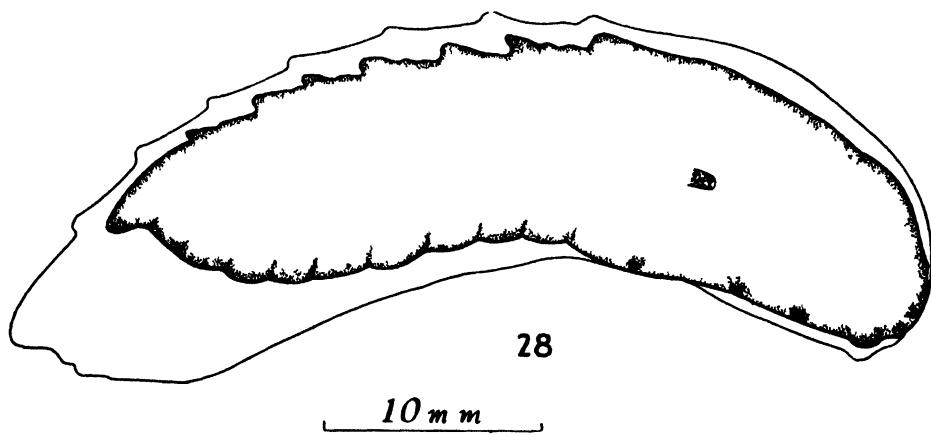


FIG. 28.—*C. antestiae*. Fifth parasitic instar larva, male.

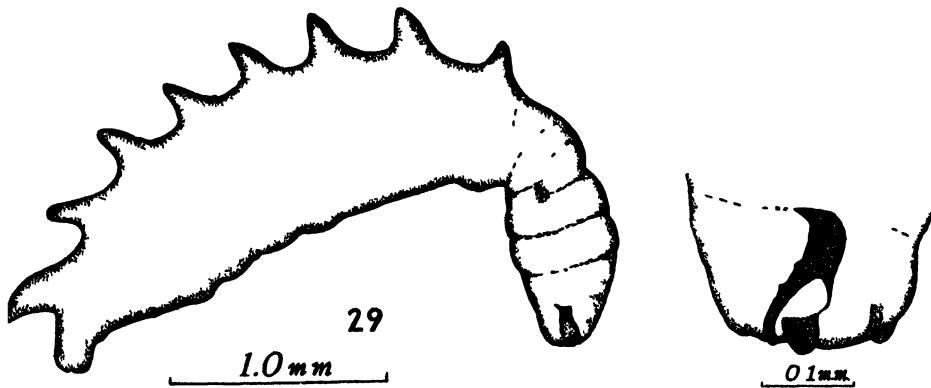


FIG. 29.—*C. antestiae*. Fifth parasitic instar larva, female.

FIG. 29a.—*C. antestiae*. Head of same.

has attained its normal size.) The spiracles, but not the mouth-parts nor any other part of the cephalothorax, are now sclerotised. The female larva (figs. 29, 29a) is about 3.3 mm. in length, i.e. very little larger than the previous instar. The spiracles and mouth-parts, but not the rest of the cephalothorax, are sclerotised. The cephalothorax is more or less permanently bent downwards almost at right angles.

The seventh (sixth parasitic) instar:

In the male (figs. 30, 30a, also Blair's fig. 5) the mouth-parts are sclerotised and there are sclerotised plates on the cephalothorax, which is ventrally

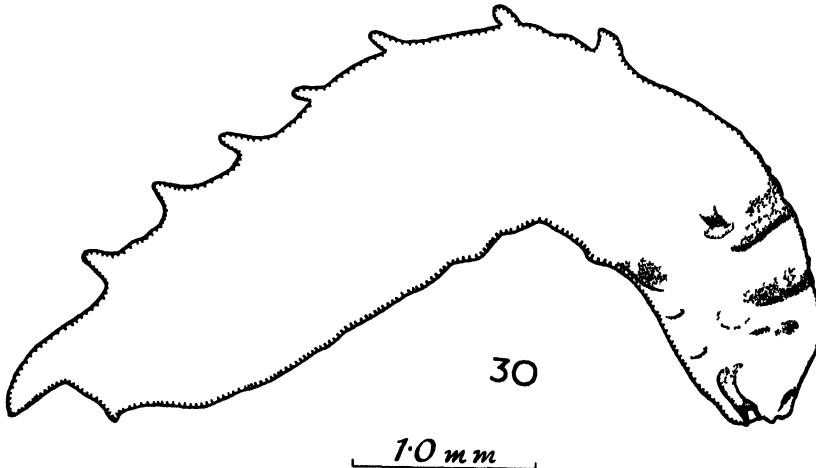


FIG. 30.—*C. antestiae*. Sixth parasitic instar larva, male before extrusion.

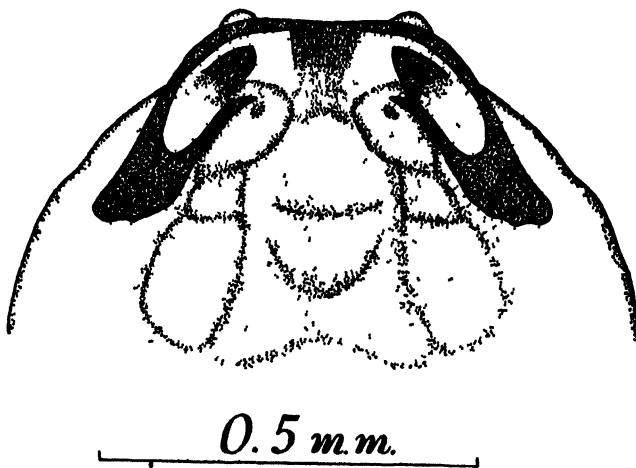


FIG. 30a.—*C. antestiae*. Head of same, ventral view.

deflected more than in previous instars. At its maximum size the larva is about 5.0 mm. in length. During this stage extrusion takes place, after which the

cephalothorax becomes strongly sclerotised and dark brown in colour (figs. 31, 31a).

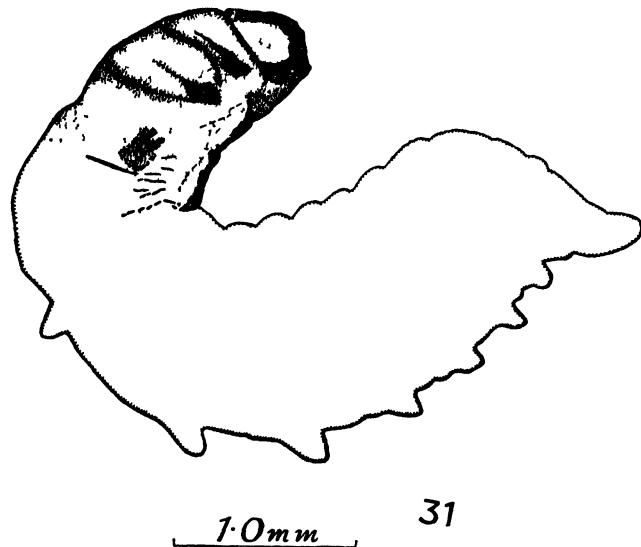


FIG. 31.—*C. antestiae*. Sixth parasitic instar, male, after extrusion.

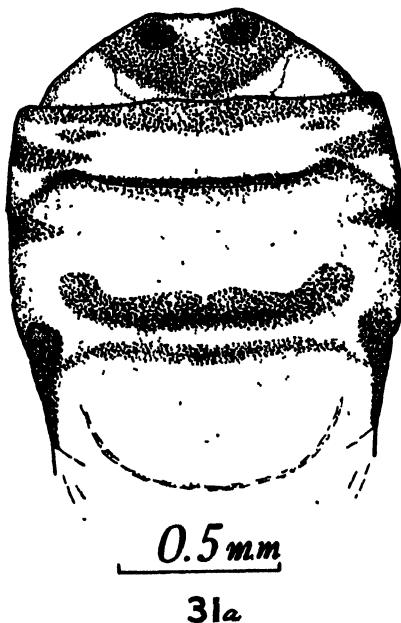


FIG. 31a.—*C. antestiae*. Cephalothorax of same, dorsal view.

The female larva of the sixth parasitic instar is about 3.6 mm. long. Before extrusion (fig. 32) the cephalothorax is slightly sclerotised and the "windows" (the pair of genital openings) become visible. After extrusion the cephalothorax becomes strongly sclerotised and chestnut brown in colour.

The eighth (pupal) instar of the male.

Soon after extrusion the male larva pupates within the skin of the last larval instar. The pupa is retracted from the exserted cephalothorax and is therefore entirely enclosed within the body of the host. The integument of the male pupa is very delicate. A few days before the adult male emerges the pupal integument is completely shed and pushed down to the posterior extremity of the last larval skin. The duration of the adult stadium is therefore in reality much longer than the two or three hours which are the span of its free active life.

There is nothing corresponding to a pupal instar in the female, the adult being formed within the close-fitting skin of the last larval instar. A female can be recognised as adult by the presence of the slightly sclerotised ventral abdominal band (fig. 16).

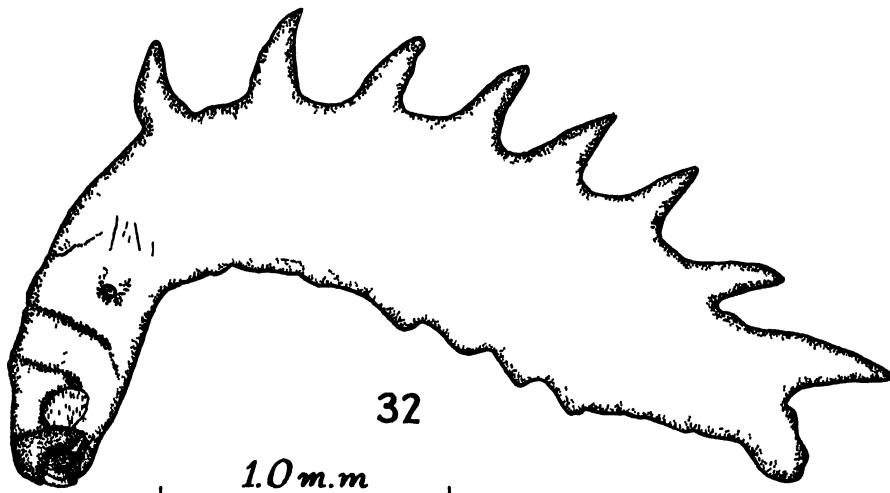


FIG. 32.—*C. antestiae*. Sixth parasitic instar larva, female, before extrusion.

(2) OUTLINE OF THE LIFE-HISTORY.

In order to avoid frequent repetitions and explanations in the following pages, it seems convenient to begin with a brief outline of the life-history of this parasite, for although in general it resembles that of most other species of Strepsiptera, so far as any information is available about them, there are several important points that are here made known for the first time.

Except where another species is mentioned, "Antestia" or "the host" refers to *A. lineaticollis* Stål, the species on which the greater number of experiments and observations has been made. Information concerning the stylopisation of other species of *Antestia* is given in Part III, Section 9.

The term "triungulin" is used to describe the free-living, campodeiform first-instar larva. This term has been used by the majority of those who have written about Strepsiptera, and while it is true, as pointed out by Perkins (1905), that the free-living larvae of Strepsiptera lack the very feature—the three-clawed last tarsal segment—on which the word triungulin is founded, yet there

seems little to be gained by adopting the word "triungulinid" and still less by coining a new term, such as pseudo-triungulin or planidioïd.

"Maternal host" or "parturient host" means an *Antestia* containing a female *Corioxenos* that has been fertilised and is producing triungulins.

"Potential host" means a nymph of *Antestia* spp. to which triungulins have attached themselves, but which has not yet been penetrated by them.

The triungulins emerge from the body of the female *Corioxenos*, escaping through the cephalothorax, and crawl about on the body of their maternal host, from which they become detached either by jumping from it or by coming in contact with some object.

Having left their maternal host they spend most of the time motionless, in an attitude well adapted for being picked up. At intervals they crawl short distances before resuming the same posture—referred to as "the waiting attitude." They are able to exist for at least a fortnight, under suitable conditions, without finding a potential host; they are quite remarkably resistant to adverse weather.

If picked up by any insect other than an immature *Antestia* they leave it again at the first opportunity. When, however, they become attached to a potential host they adopt a different posture, and it is then extremely difficult to dislodge them.

They do not immediately penetrate a potential host, but remain motionless on its exterior until its next ecdysis, when they are able to penetrate it.

When attached to a potential host they can remain alive for a very long time, 34 days being the maximum recorded with certainty, and it is only exceptionally that an *Antestia* fails to moult within a much shorter period than this. They can penetrate at any of the five ecdyses. Between two and five days after penetration the integument of the triungulin splits transversely between the head and thorax, and the first parasitic instar larva emerges into the body cavity of the host. There are probably six parasitic instars before the fully-grown (seventh parasitic instar) larva of either sex extrudes its cephalothorax from the body of the host. The parasitic instars feed on the blood of the host by diffusion through their skin. No direct damage is done to the organs of the host, such atrophy as occurs being literally atrophy, i.e. due to lack of nourishment consequent upon the presence of the parasite.

Extrusion of the cephalothorax, which cannot occur until the host has become adult, is invariably between the third and fourth abdominal tergites (i.e. between the *apparent* first and second tergites) (fig. 35). Only the actual cephalothorax is extruded, the whole of the abdomen including the sclerotised first segment which is united with the cephalothorax, remains within the body of the host.

Female larvae (with no exceptions) are extruded close to the pleura and male larvae (with very few exceptions) as near the middle as possible. The period of development, from entry of the triungulin to extrusion of the mature larva, is somewhat longer for a male than for a female. A male larva pupates very soon after extrusion, but the pupal stage is of comparatively long duration, so that the total period of development is over half as long again for a male as for a female. A female larva, without any intervening pupal stage, becomes adult and capable of being fertilised a few days after extrusion of the cephalothorax.

The males always emerge in the morning; they live a free active life of some two to three hours only, during which time they can copulate with as many females as time and opportunity allow.

The females never leave the host; copulation is effected by the male piercing with its aedeagus one of the "windows," situated on either side of the female's cephalothorax, which is on the outer side in relation to the host. Parthenogenesis never occurs. A female can be fertilised at any time during a period of about five to eight weeks. After this its ova degenerate and though copulation may take place, fertilisation does not follow. A single act of copulation, lasting perhaps a few seconds, is as efficient in procuring fertilisation as repeated acts either by the same male on one day, or by other males on following days.

The period of incubation, from fertilisation to the emergence of the triungulins from their maternal host, is usually between six and nine weeks, according to the temperature. A single fertilised female can produce over 3500 triungulins, during a period of about three months.

(3) THE FREE-LIVING, OR TRIUNGULIN, LARVA.

(a) *Emergence.*

The triungulins emerge from the female either through the oral aperture, or through the opening, previously made by the aedeagus of the male, in the "window" on the outer side of the female. In many (possibly most) cases the hole thus made appears to be insufficiently large and the triungulins escape only through the oral aperture.

They emerge at any hour of the day and also during the night, though judging from individuals kept in the laboratory, rather more seem to appear during the afternoon, and rather fewer at night, than at other times.

Having got clear of their parent, they crawl about on their maternal host for a period which varies between a minute or two and several days. They become detached from the *Antestia* either by jumping from it or by coming into contact with any part of the coffee bush on which it is feeding, or with some other insect.

(b) *Locomotion.*

They move in short jerks, at the rate of about one mm. in thirty-five seconds in cool weather, but less slowly in warmer weather or if exposed to the sun. At a temperature of 25° C., in the laboratory, the average rate of progression (ten journeys by five different individuals) was one mm. in fifteen seconds, and it was much the same on a cool day but in full sunlight out of doors. Although most authors who have described the habits of the triungulins of other species of Strepsiptera have referred to them as "exceedingly active," this can scarcely be said to be true of the species considered here. One of the longest uninterrupted journeys recorded was of 4.2 mm. in 80 seconds. They do not as a rule continue moving for more than a minute or less at a time without stopping and adopting the "waiting attitude."

In this position, in which they spend most of the time until they either get picked up by a potential host, or die, the two anterior pairs of legs (of which the last tarsal segment is provided with an adhesive empodium) are held in the air, the front pair projecting forwards at an angle of 45°, and the middle pair at right angles to the body. This is raised at an angle of about 40° and is supported by the hind pair of legs and the central pair of tail bristles. The tarsi of the hind legs project forwards and the central tail bristles are doubled up under the body, the lateral pair of tail bristles being held in the air (fig. 33).

In order to adopt this position they grip with the two anterior pairs of legs, raise the abdomen high into the air, and bend the central tail bristles downwards and forwards under the abdomen, which is then lowered. Poised



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FIG. 33.—*C. antestiae*. Diagram of triungulin in "waiting attitude."

in this way they are perfectly adapted for fastening on to any moving object which encounters them. They frequently stay in this position for hours (if not days) at a time, either quite motionless or sometimes swaying a little from side to side, subsequently moving perhaps only a very short distance and then adopting the same attitude again.

(c) *Tropisms*.

The triungulins are positively phototropic, though not very definitely so. If numbers of them are placed on a sheet of paper in front of a window, nearly all will adopt the waiting attitude facing the light. Similarly the majority, but by no means all, tend to crawl towards a source of light. On the other hand, just as many seem to remain on the shaded side of a coffee berry as on the side exposed to the sun. They are neither positively nor negatively geotropic. They are definitely not stereotropic, except when they are attached to a potential host. It is obvious that if they were inclined to hide in crevices they would stand less chance of being picked up.

Numerous experiments to find out whether they were attracted towards the smell of a nymphal *Antestia* gave no positive results; this being so, it can only be said that it is unexplained how, having been picked up by an immature *Antestia*, they should "know" that they have found a potential host, and not allow themselves to be detached from it.

When they are in the waiting attitude the triungulins are able to jump a considerable distance, at least ten mm. vertically and nearly twenty-five mm. horizontally. The exact mechanism by which the jump is effected is not known, since it takes place much too quickly for any precise details to be observed. Probably the hind legs are the main source of propulsion, but the doubled-under tail bristles may also to some extent serve as a spring. Ability to jump has also been recorded for the triungulins of other species of Strepsiptera (Saunders, 1853).

They seldom, perhaps never, jump unless stimulated to do so by the near approach of some object, and it is only by objects of certain colours that any large proportion is attracted. Detailed evidence for this somewhat remarkable faculty for distinguishing colours has been given in a separate publication (Kirkpatrick, 1937).

It will suffice to say here that the attractive colours are red, black and orange. White, green and blue are comparatively non-attractive. Pure yellow is intermediate, but the addition of a little orange makes it definitely attractive.

Black and orange are the predominant colours of *Antestia*, so that it is probable that this faculty of colour vision enables rather more triungulins to find a potential host than would otherwise do so. But it must be admitted that so far as observations go, far more seem to become attached to an *Antestia* nymph through direct contact than by jumping on to it.

(d) *Transportation.*

When in the waiting attitude, and also, though a little less readily, when crawling, they will immediately attach themselves to any moving object, such as another insect, that happens to touch them. Should this object be anything except an immature *Antestia* they usually leave it at the first opportunity, which means that in most cases they get off again on to some part of the coffee bush at a greater or lesser distance, according to the activity of the insect to which they become temporarily attached, from where they were picked up. It will be clear from what has already been said about their slow and infrequent movements, that unless the triungulins should be transported they would not move far from the place where they became detached from their maternal host. A dead *Antestia* containing a parturient female was pinned on a leaf of a small coffee plant on which no other insects were present; after four days a few triungulins were found up to six inches away, but the great majority had moved two inches or less, and were still either on the same leaf or on the one immediately above or below it.

The list of insects to which I have observed triungulins to become attached comprises practically all those with which experiments have been made, and includes species of the orders Orthoptera, Hemiptera, Coleoptera, Hymenoptera and Diptera, and also (in the laboratory) the adult male of their own species.

From the majority of these, as has been said, they detach themselves at the first opportunity. I have, however, observed that large numbers picked up by a Hispid beetle were unable to free themselves from its spines. Doubtless there are other insects that, either from excessive hairiness or the presence of a secretion, prove fatal to the triungulins.

It is probable that they sometimes get attached to aerial insects that are on the point of leaving the coffee bush, and thus get deposited in a place where they would have no chance of finding a host.

This habit the triungulins have of utilising other insects as vectors is perhaps scarcely to be considered as a genuine case of phoresy* since, though of frequent occurrence, it is purely fortuitous. The habit must, however, inevitably result in the wider distribution of the triungulins and in the

* Phoresy is a term proposed by Lesne (1896) for the phenomenon of one animal apparently deliberately and for its own benefit utilising another as a vehicle of transportation. Lesne's typical example was a saprophagous Borborid fly, which rides on the back of a dung-beetle and oviposits in the ball of dung that the beetle constructs. Most other examples of genuine phoresy are concerned with parasites, such as certain Scelionid egg-parasites of Orthoptera, of which the adult attaches itself to the female host on which it remains until the host oviposits, when it lays its own eggs in the egg-mass of the host. (Chopard (1922), quoted by Imms (1931).)

One of the most extraordinary instances is the case of *Dermatobia hominis* Say—the “human bot-fly.” This fly is said to haunt the breeding-places of mosquitos, capture the adult mosquitos as they emerge, and lay its eggs upon them. When the mosquito begins to feed upon a man the eggs (which already contain mature first-instar larvae) hatch, presumably owing to the warmth imparted, and penetrate the skin. (Curran, 1934.)

The procedure adopted by *Corioxenos* is much less remarkable and more haphazard than the above, but it is of too frequent occurrence to be dismissed as mere accidental transportation.

survival of a greater number of individuals than if they were only distributed by their maternal hosts. The following experiment gives an indication, though under highly artificial conditions, of the efficacy of the distribution of the triungulins by another insect. A fifth-instar nymph (of which the prevailing colours are black and orange) of a species of *Nezara* was confined for one hour in a small cage containing a coffee berry on which were 25 triungulins. It was then transferred to another cage containing two third-instar *Antestia* nymphs and left there for 18 hours before removal. In one of these hosts seven *Corioxenos* developed and in the other three.

The readiness of the triungulins to attach themselves to any object and then to transfer to another has proved of great assistance in experimenting with a known number of triungulins to each potential host. It is a simple matter to pick up a triungulin on the point of a needle and then to touch any part of an *Antestia* nymph, to which, in nine cases out of ten, it will adhere immediately.

(e) Survival and mortality before finding a potential host.

If the opportunity offers, a triungulin will attach itself to a nymphal *Antestia* immediately after issuing from its parent, and should that *Antestia* be on the point of moulting, it is able to burrow in at once. If, however, no potential host is immediately available, the triungulins are capable of surviving a surprisingly long time. It is probably impossible to ascertain how long this time is under normal conditions on a coffee bush. In one experiment a dead parturient host was fixed to a leaf of a small potted coffee plant, fully exposed to the sun and rain, at 09h. on 4.xii.35. Living triungulins were found on the plant up to 09h. on 10.xii.35, though none after 16h. on that day. During this period of six days the mornings were mainly sunny, and a total of 25.3 mm. of rain fell, including one shower of 13.4 mm. in 30 minutes.

In another similar experiment a dead parturient host was attached to a small exposed coffee plant on 14.xii.35 and removed on the morning of 18.xii.35. In the afternoon of that day a nymphal *Antestia* was allowed to walk about on the plant for five minutes. It was observed to have picked up a number of triungulins, five of which subsequently penetrated and developed. On 18.xii, 3.4 mm. of rain fell in 8 minutes; and on 19.xii, 9.6 mm., of which, so far as could be judged from the chart of the recording rain-gauge, 6 mm. fell in less than five minutes. A few triungulins were still present on 20.xii, though on the following day none could be found. In experiments in which triungulins were placed in the middle of a large sheet of blotting-paper fastened on a board and fully exposed to sun and rain, some have been found alive after 73 hours, but the majority were washed off the paper by heavy rain and may not necessarily have been killed.

Experiments under artificial conditions indicate that they are capable of surviving for much longer periods than might be inferred from the foregoing.

(a) At a relative humidity maintained constant at 86% (the average maximum temperature during the period being 26° and the average minimum 20.2°), nearly all survived for 15 days and some for 19 days. This is the longest recorded time for which they have survived without finding a host, though I have many records (Table 12) of their having lived for much longer periods externally on a host, when a delayed

ecdysis on the part of the latter has postponed their chance of penetrating it.

(b) In a cardboard box in the laboratory, the relative humidity uncontrolled (varying from about 70% to 90%), the average maximum temperature being 24.5° and the average minimum 21.5°, some survived for 15 days.

(c) At a relative humidity of 100%, two out of twenty-five lived for twelve days, but the others had previously become entangled in the hyphae of a fungus, and died.

(d) At a constant relative humidity of 30%, most survived 84 hours but all were dead in 96 hours.

(e) About 25% of those kept at a constant relative humidity of 10% lived for 72 hours, but all were dead in 80 hours.

(f) Kept in a refrigerator at an almost constant temperature of 4.5°, all survived for 48 hours, and started moving within ten minutes of being taken out. The same ones were put back into an almost constant temperature of 0° for a further 30 hours, after which about 70% of them had died, but the remainder recovered.

Their resistance to high temperatures for short periods was tested by placing numbers of triungulins on a piece of blotting-paper enclosed in a small glass tube immersed in a water bath. A thermometer inserted through the cork of the tube presumably gave a close indication of the temperature to which the triungulins were subjected.

(g) Subjected for ten minutes to a temperature of 49.0° rising to 49.5° at the end of the period, after four minutes all were exceedingly active; after seven minutes nearly all had ceased moving, and at the end of the ten minutes all were inactive, lying flat on the paper, *i.e.* not in the usual waiting attitude. One hour after being restored to the normal room temperature of about 25° all were still lying motionless and flat. Three hours after, one or two showed signs of movement, and on being picked up on the point of a needle, fourteen were found to be alive and attached themselves readily to an *Antestia*; the remaining eighteen were apparently dead. Of these fourteen, five (at least) were observed to enter the *Antestia* at its fourth ecdysis, which took place on the following day, and four of these completed their development.

(h) Ten triungulins were subjected to a temperature of 43.0°, rising at the end of the period to 45°. The majority moved actively for thirteen minutes, being in fact much more active than at normal temperatures, and never remained in the waiting attitude for more than a few seconds at a time. After seventeen minutes all had become motionless and were lying flat. They were then removed. Some showed signs of life two minutes later, and after two hours all seemed to be alive and attached themselves to a host. The host moulted four days later and it was subsequently found that seven out of the ten had penetrated and developed.

Their powers of resistance to complete immersion in water are quite extraordinary, as the following experiments show:—

(i) Eight triungulins were immersed in distilled water for four hours, then exposed to the noon-day sun for one hour, after which they were put on a fourth-instar nymph. The nymph moulted three days later;

six out of the eight penetrated and developed, five (three males and two females) arriving at maturity.

In the following six experiments (*j-o*) a large number of triungulins (which incidentally had emerged from a female in a host that had died four days previously) were immersed in distilled water for seventeen hours; they were then dried in the sun from 08h.30 to 10h.30 on 13.xi.35. Very nearly all of them survived this treatment and they were then placed on six fourth-instar nymphs, ten being put on each nymph, with the following results:—

(*j*) Two days to next ecdysis of host. Four penetrated and developed, of which all (three males and one female) arrived at maturity.

(*k*) Nine days to next ecdysis of host. Four penetrated and developed, of which all (two males and two females) arrived at maturity.

(*l*) One day to next ecdysis of host. Seven penetrated and developed, of which two females arrived at maturity, but the host died prematurely, since it also contained four fully grown male larvae and one female larva.

(*m*) Two days to next ecdysis of host. Six penetrated and developed, of which three females became adult and two males and one female failed to become exserted.

(*n*) One day to next ecdysis of host. Seven penetrated and developed but the host died before any became adult; it contained five sixth-instar male larvae and two fully grown female larvae.

(*o*) Two days to next ecdysis of host. Three penetrated and developed, all three (two males and one female) becoming adult.

Thus of the 60 triungulins which in these experiments were put on to six potential hosts 31 entered and developed, a proportion comparable to that successful in developing under normal laboratory conditions (Table 12).

(*p*) Ten triungulins were immersed in 1% NaCl solution for 72 hours. On being dried in the sun, nine of them were found to be still alive. These readily attached themselves to a nymph, but none of them succeeded in penetrating at the next ecdysis (to the fifth instar) which took place ten days later.

(*q*) After 96 hours immersion in 1% NaCl solution, no triungulin out of a large number survived. Most of them had swollen so that the intersegmental membrane had become visible, and they appeared as if they were on the point of moulting to the first parasitic instar, though none of them did so.

Since it was suggested to me that spraying with Bordeaux mixture, which on many estates is carried out as a routine practice against *Homileia* and leaf-fall, might be injurious to the triungulins, the following experiment was made:—

(*r*) Twenty triungulins were immersed for fifteen seconds in a Bordeaux mixture nearly twice as strong as that normally employed, and then left for an hour to dry. They were then all alive and ten were put on each of two fourth-instar *Antestia*, which moulted eleven and fourteen days later. Five larvae developed in each host, producing three adult males, four extruded females and three females unable to extrude.

The foregoing experiments are at least sufficient to show that the triungulins are not likely to be destroyed in large numbers by any ordinary weather conditions. Moreover, even if prolonged wet weather may at times be responsible for some mortality among them, it must be remembered that a parturient female, provided that its host survives, is capable of producing young over a period of at least three months, so that the proportion of her total brood destroyed by weather conditions could at most be small.

The triungulins are, however, readily caught and killed by any sticky substance. In a small cage, many are entrapped in the excreta of *Antestia*, and (though this has not been verified by observation) I should expect that on a bush on which Coccids or Aphids were numerous large numbers would become stuck in the honey-dew.

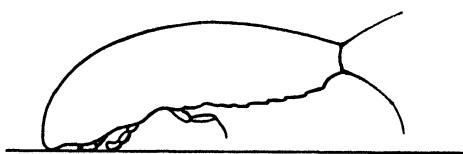
Triungulins are able to emerge from a female contained in a dead host for at least seven days after its death, provided of course that the conditions are such that the body of the host remains moist. Under field conditions it is probable that it would dry up in a much shorter time. Such triungulins have just as much vitality and power of survival as those that have emerged from a living host. It has also been proved that triungulins emerging from females contained in *Antestia* that were moribund, or had actually died, as a result of arsenical bait spray (Part I, Sections 7, 8) were quite healthy and capable of survival.

No predators on the triungulins have been observed, and, though this is not to say that none exists, it seems unlikely that any predaceous species would be sufficiently attracted by such a small and tough insect to cause appreciable mortality.

It therefore seems probable that the chances of the survival of a triungulin depend almost entirely on its finding a host—or rather on a host finding it—within a period of, say, about ten days.

(f) *Attachment to potential hosts.*

If an *Antestia* nymph walks over any surface on which triungulins are present in large numbers, it picks them up in a manner that reminds one of a carpet-sweeper. Most of the triungulins adhere in the first place to the legs, a few to the antennae, and some to the ventral surface of the abdomen. The *Antestia* usually tries to remove them from its antennae, though they then frequently adhere to the front legs, used for dislodging them.



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FIG. 34.—*C. antestiae*. Diagram of triungulin in the attitude adopted when on a potential host.

Having got on to a young *Antestia*, the triungulins crawl about until they have found a suitable spot from which they cannot be, or at least are unlikely to be, removed. The most usual places are almost anywhere on the dorsum of the thorax or abdomen, on the sternum between the coxae, or between the head and thorax. When once they have settled down they seldom, if ever, move again until the next ecdysis of the host, they never adopt the

waiting attitude, and it is difficult to dislodge them without injuring them. Their position (fig. 34) is, in fact, the exact opposite of the waiting attitude. They grip the potential host with the two front pairs of legs and also, it appears, take some sort of hold with their mouth-parts, since if they are pushed from the side with the point of a needle they can be pivoted round on their heads without being dislodged. The abdomen is held in a convex position, the hind legs and the tail bristles being raised above the surface of the *Antestia*.

That they do occasionally leave a potential host, though whether voluntarily or not cannot be said, is suggested by the fact that on a few occasions, in experiments where a known number of triungulins were placed on each nymph of several kept together in the same cage, some of the individual hosts have developed more parasites than the number of triungulins placed on them. This may possibly be explained by the fact that triungulins sometimes get left behind on the exuviae of a nymph that has moulted, and may then transfer themselves to another nymph.

The triungulins are able to penetrate an *Antestia* at any of the five ecdyses, including the final one to the adult instar, but not on its eclosion from the egg, although to all appearances the first-instar nymph immediately after hatching is as pale and soft as a recently moulted one. Several experiments have been made in which triungulins were put on or near batches of eggs on the point of hatching, and though many attached themselves to the newly hatched nymphs, none attempted to penetrate.

The triungulins undoubtedly leave, or get detached from, nymphs of the first instar more readily than those of later stages; consequently the proportion of triungulins that attach themselves to nymphs of the first instar and successfully penetrate at the first ecdysis, is rather lower than the proportion that penetrate at any of the succeeding ecdyses except the final one (Table 12). In an experiment in which four triungulins were put on to each of twelve first-instar nymphs, twenty-five penetrated and developed. Of these five for certain, and probably three others, did not penetrate until the second ecdysis. It is, moreover, unlikely that second-instar nymphs often become stylopised in the field, for during the first stadium *Antestia* nymphs are practically immobile, seldom moving far from their empty egg-shells, and taking little or no food. Consequently they would not as a rule meet with triungulins unless a host containing a parturient female, or a "vector" insect should chance to walk into a cluster of newly-hatched nymphs.

They do not search for a host with any semblance of "purpose": a nymphal *Antestia* may pass within a millimetre or less of a triungulin and the latter, unless it jumps on to the *Antestia*, will show no sign of recognition. But a triungulin actually touched by a nymph will adhere immediately.

(g) *The method of penetrating a host.*

As has been said, when a triungulin gets attached to an immature *Antestia* it quickly settles down and remains motionless until the next ecdysis of the host.

The act of penetration into the host has been watched on numerous occasions. As soon as the host starts to shed its skin, the triungulins present become exceedingly active, whatever the time of day or night, and regardless of temperature. They do not, however, appear to have much sense of direction, and have even been observed to walk back from the body of the new instar

nymph, which is their objective, on to the almost completely shed exuviae, on which they have been left behind. When they succeed in getting on to the soft pale body of the newly moulted host, they usually start burrowing into it within a few minutes. As a rule they bore in obliquely, though sometimes they have been observed to do so almost vertically. From the time they begin to penetrate until they are completely out of sight is usually about fifteen minutes.

They have been observed to penetrate almost any part of the host. The pronotum is the most usual place, but possibly only because this is where the majority of triungulins find themselves when they have left the partly shed exuviae. Or it may be (if there is any truth in the hypothesis that it is the moult fluid which stimulates them to activity and penetration) because the glands secreting the moult fluid are more numerous on the pronotum than elsewhere. That this is so in *Antestia* has not been verified, but it is said to be the case in the majority of insects (Comstock, 1925). Other places at which they have been observed to penetrate are the cervicum, any part of the thoracic sterna, particularly close to the coxae, and (much less frequently) the abdomen, either dorsal or ventral surfaces. They have on several occasions been seen to penetrate, in hosts that had just moulted to adult, the scutellum and corium. Thence, if they are to reach the body cavity and survive, they must go right through and burrow again through the tergum. I have no evidence that they ever succeed in doing this, and I know that in a few of the instances where a triungulin entered the scutellum, it failed to penetrate further.

It will be seen from Table 12 that the proportion of triungulins that succeed in developing when they have become attached to a fifth-instar nymph, and should therefore penetrate at the final moult, is smaller than the proportion that are successful at the four previous ecdyses. At least part of the difference may be accounted for by those which, in attempting to penetrate the newly moulted adult, enter the scutellum or corium and are unable to progress further.

If triungulins do not start penetration within about 20-30 minutes from the beginning of ecdysis they seem unable to accomplish it. I have several times observed triungulins to get on to a newly moulted host but fail to penetrate, although many of them remained alive until the host's next ecdysis, when they succeeded in penetrating. Such cases are, however, comparatively uncommon, the majority of those recorded being of triungulins that became attached to a first-instar nymph, and succeeded in getting on to the second instar but did not penetrate until the second ecdysis. At the subsequent ecdyses nearly all the triungulins that leave the exuviae and attach themselves to the new instar are successful in boring into it.

I am still uncertain what the stimulus is which, when the host starts moult, urges the triungulin to activity, although it has been completely motionless for the whole time since it became attached. It might possibly be a chemical stimulus provided by the "moult fluid." Yet at the time of ecdysis the moult fluid appears to have been almost completely absorbed, and the skin of the new instar to be quite dry, as it is, according to Wigglesworth (1933), with most insects.

Moreover, several experiments were made in which a clean needle was rubbed on an *Antestia* in the act of moult and then brought into close proximity with triungulins immobile on the back of another nymphal host, but no response was ever evoked. Neither were active triungulins, crawling

about on a piece of paper, attracted to a part of the paper that had been rubbed with a moulted nymph. The negative result of these experiments is, of course, not conclusive, and the suggestion that the moulted fluid is the stimulus may perhaps be supported by the fact that triungulins will not penetrate first-instar *Antestia*, although on eclosion from the egg they are just as soft as they are after an ecdysis. The curious fact (discussed in Part III, Section 5) that triungulins seldom penetrate hosts with malformed antennae may also possibly be explained by such hosts being deficient in the glands secreting the moulted fluid. I have also noticed that triungulins very rarely attempt to enter a host that dies shortly after an ecdysis, because it could not completely free itself from the exuviae. On the other hand, the triungulins are, under certain circumstances which are discussed below, occasionally capable of entering an *Antestia* long after it has become adult, when there could be no question of the moulted fluid acting as a stimulus.

(h) *Survival and mortality when attached externally to a potential host.*

Apart from the not very frequent instances, mentioned previously, in which a triungulin attaches itself to the new instar after ecdysis, but fails to penetrate, the time for which it must survive externally on the host, if it is to develop further, depends on the period elapsing between its finding a host and the next ecdysis of the latter. The maximum period is therefore determined by the duration of the various stadia of *Antestia*. Tables 1-5 (in Part I) summarise all the information I have been able to collect on the duration of the five stadia, under laboratory conditions, with abundant food and under different conditions of temperature.

Temperature has a very large effect on the duration of the stadia, at least on the average duration, but I have several records of an individual bug, hatched from the same batch of eggs as others which have developed in normal time, and kept under identical conditions, being much slower than the average in developing. It is, however, a comparatively rare occurrence for a stadium to last so long that all the attached triungulins have died before the next ecdysis.

Table 12* shows, for a total of 6764 triungulins put on to 1000 *Antestia* kept in the laboratory, the proportion that survived until the next ecdysis and then succeeded in penetrating and developing, in relation to the number of days it was necessary for them to remain externally on their potential host; and in relation to the particular ecdysis of the host at which they entered. The number placed on each nymph varied between one and fifteen, but was usually five or seven, less often ten. I have already explained how simple a matter it is to pick up a triungulin on the point of a needle and transfer it to a potential host. The nymphs were kept separately, each in a small cylinder of celluloid, resting on blotting-paper and covered with a glass plate. All were fed on full-sized but still green coffee berries.

Of the total of 6764 triungulins placed on these 1000 potential hosts, 3446 or 51% succeeded in developing.

It will be seen from the right-hand column of each section of the table that there is, as was to be expected, a progressive decrease in the number of survivors according to the time elapsing between the triungulins becoming attached and their entry into the host at its next ecdysis. This decrease is, however, very small for the first nine days, and even if the triungulins have to remain externally

* Nymphs with malformed antennae (Part III, Section 5) are not included in this table.

TABLE 12.
Survival rates of trinucleins of *Coriozenos*.

No. of days from attachment of tritumgullus to next brood of potential host		Adult		Fifth		Fourth		Third		Second		Total (all instars)		
1-3	21	3	171	84	576	57·0	115	2	632	437	25	0	135	72·6
4-6	33	4	266	98	326	55·6	99	2	599	401	71	108	76	58·7
7-9	35	3	212	66	31·2	50	1	327	194	61·7	20	0	130	56·5
10-12	35	3	255	81	31·7	45	1	220	154	47·5	40	1	254	58·3
13-15	30	5	268	86	32·0	42	1	316	153	47·9	34	1	214	55·6
16-20	27	2	279	84	28	2	218	99	45·4	14	1	72	58·9	
21-25	15	6	149	16	10·7	6	1	45	13	28·9	2	1	5	2
26-30	4	1	28	6	21·4	2	1	13	2	—	0	—	—	—
31-35	1	1	5	0	—	—	1	5	3	43	2	—	—	—
36-40	—	—	—	—	—	—	—	2	9	0	—	—	—	—
Total	192	26	1633	900	30·6	315	11	2299	1227	52·8	371	14	1352	61·4

on a potential host for as long as twenty days, the proportion surviving is still over 40%, or about 80% of the average survival. After 20 days the mortality appears to increase considerably, but the number of potential hosts that fail to moult within this time is naturally small. The longest time for which triungulins have been known to survive externally on a potential host, and then to succeed in developing, is 34 days in two instances, in one of which one out of fifteen, and in the other one out of five, survived for this length of time. Many have survived for more than 19 days, which is the longest time they have been known to exist in the absence of a potential host.

Since the triungulins do not feed, whether they have found a potential host or not, it is probable that their ability to survive longer when on an *Antestia* is due to decreased metabolism consequent upon cessation of activity.

The ecdysis of the host at which the triungulins enter has a distinct bearing on the proportion that are able to develop. Of those due to penetrate at the second or third ecdysis, *i.e.* entering the third or fourth-instar nymph, the survival rate is over 60%. Why it is distinctly less; under 53%, when they are due to enter at the fourth ecdysis, is unexplained. It was to be expected that rather fewer (47.3%) would survive when placed on first-instar nymphs, since they are known to become detached from these more readily than from the later stages. I do not, however, fully understand why the survival rate of those that were placed on fifth-instar nymphs, and therefore ought to have penetrated when the host became adult, should be as low as 30.6%. To some extent this is accounted for by the fact that some of the triungulins enter the scutellum and the corium of a host that has just moulted to the adult instar, and I believe that these fail to penetrate to the body cavity. But I do not think that a sufficient number do this to account for such a large reduction in the survival rate. It will also be observed from Table 12 that of 192 potential hosts of the fifth instar, 26, or nearly 14%, failed to become stylopised at all. On the assumption that all potential hosts are equally liable to be stylopised, this proportion is far in excess of the mathematical expectation, whereas of 775 hosts of the fourth, third and second instars, only 27 failed to become stylopised, a number only about twice as great as the theoretical probability.

There is therefore little doubt that for some unexplained reason attachment to a fifth-instar nymph gives a triungulin a poorer chance of survival than does attachment to an earlier instar.

Under field conditions the proportion of triungulins that succeed in finding a potential host is naturally a very small fraction of what it is under the sheltered and confined conditions of cages in an insectary. To maintain the species in stable equilibrium it is only necessary for about two of the progeny of each female, or, say, 0.2%, to survive to maturity. (The fact that one male is capable of fertilising several females, and therefore that it is not necessary for an average of one male from each parent to survive, is probably roughly balanced by the cases in which a female fails to become fertilised and by those in which the host dies before the female parasites it contains have produced triungulins.)

At what stage the enormous mortality of the triungulins occurs can only be conjectured, but I think that it is almost entirely due to failure to find a host, and that of those which are successful in finding a host the proportion of survivors is likely to be almost as large in the field as in the laboratory.

Antestia nymphs with triungulins attached externally have been exposed to heavy rain and hot sunshine without any effect on the triungulins, a normal proportion of which have penetrated at the next ecdysis. Fifteen nymphs of the third and fourth instars were enclosed in a wire gauze cage on a part of a

coffee bush, together with one adult *Antestia* containing one parturient female *Corioxenos*. This was left for seven days and then removed; after all the nymphs had undergone an ecdysis these were also removed and kept singly in the laboratory until they died. (Those containing eight or more parasites died prematurely.) They were found to contain the following numbers of parasites: 16, 16, 15, 12, 11, 11, 10, 10, 9, 8, 5, 5, 4, 4, 2, or a total of 138. Assuming that during the seven days for which the parturient host was on the tree it gave birth to 90 triungulins per day (a rate slightly higher than the maximum recorded in the laboratory), then 22% of the 630 produced were picked up, penetrated and developed. This large percentage is, of course, accounted for by the fact that the parturient host and the fifteen nymphs were confined together in a comparatively small space. The wire gauze used for the cage was of the widest mesh that would prevent the escape of the nymphs, and could not have afforded any considerable protection. During the period that they were on the tree (31.x.-15.xi.35) 19 mm. of rain fell, including one shower of 6 mm. at the approximate rate of 1 mm. per minute, and there was bright sunshine on the majority of the mornings.

In another experiment ten triungulins were placed on each of ten fourth-instar nymphs, which were then liberated on a small isolated coffee bush, completely unprotected in any way, on 4.v.36 and left there until 23.v.36. At the end of this period, during which a total of 250 mm. of rain fell, only four out of the ten *Antestia* were recovered. In one of these six *Corioxenos* developed, in two of them five each; the remaining one had not moulted, but a single triungulin was still alive on it externally. This was transferred to a fresh nymph which moulted two days later. It successfully penetrated and eventually became an adult male.

I have frequently watched triungulins in the act of penetrating an *Antestia* and even when the number was large, twenty or more, the host never showed any signs of discomfort.

The number of triungulins that will, given the opportunity, penetrate a host is governed only by the number that can find room to attach themselves. Several experiments were made in which nymphs were allowed to crawl about on coffee berries covered with large numbers of triungulins, until they could apparently pick up no more, and as many as sixty-six have been known to penetrate and develop—though, of course, not to maturity, since from such excessive multiple parasitism the host always dies prematurely (Part III, Section 4).

Much larger numbers of triungulins have been recorded entering an adult *Antestia* that already contained a parturient female, and developing at least to the first or second parasitic instar, as is described below.

Providing that triungulins successfully accomplish their first ecdysis, instances of subsequent premature mortality are exceedingly rare. Except when the presence of too many parasites in one host renders the extrusion of some of them impossible, I have only two or three times found dead larvae of any of the parasitic instars within a living host. There is, however, a small premature mortality (about 2%) of males that have become adult, but for some reason have been unable to free themselves completely from the pupal exuviae.

(i) *Entry into adult Antestia.*

I have shown that the normal time of entry of the triungulins into a host is immediately after an ecdysis, whether to the second, third, fourth, fifth or adult

instar. They have never been known to try to penetrate a nymph except at the time of ecdysis.

They are, however, able to enter, and develop in, an adult *Antestia* that contains extruded *Corioxenos* of either sex. Over 300 have been known to penetrate a host containing a parturient female and also the pupa-case of an emerged male. When this host died, a few of these had attained the third parasitic instar, though most were in the first and second. In addition there was a large number of unmoulted triungulins in the body cavity.

They are also able to penetrate a host that contains only a non-parturient female or a male, though comparatively few do so, since, as the host is not itself producing triungulins, it is only those it may chance to pick up that have the opportunity of entering. They appear to enter where the intersegmental membrane is broken at the point of extrusion of the mature parasite. This habit of penetrating a mature stylopised adult occurs under field conditions, but probably to a much smaller extent than when the hosts are kept in small breeding cages in the laboratory. Especially when no immature *Antestia* are present the emerging triungulins can find no suitable hosts and are constantly attaching and re-attaching themselves to the adults present.

Having penetrated into an adult *Antestia* through the intersegmental membrane, they develop normally, though I have no record of their doing so beyond the male pupal stage. But there seems to be no reason why with only one or two mature parasites of the original infestation, and only one or two triungulins subsequently entering, a host should not bring a second generation, as it were, to maturity. This phenomenon is exceedingly rare among insects parasitic on insects, though according to Imms (1931) a parallel has been recorded by Timberlake experimenting with the Braconid *Dinocampus coccinellae* Schr. (*americanus* Riley), which is parasitic on COCCINELLIDAE.

However, any large number of triungulins entering and developing within an already stylopised host entails, at least under laboratory conditions, the premature death of the host. In the laboratory certainly, and probably also in the field, this second-generation parasitism is disadvantageous to the parasite, for it tends to produce premature mortality among hosts containing parturient females.

Very exceptionally triungulins are able to penetrate an unstylopised adult *Antestia* and to develop within it. The place where they enter is not known; probably it is through the intersegmental membranes of the abdominal tergites. Out of over fifty adult *Antestia*, known to be unstylopised, and enclosed with very large numbers of triungulins (so many that some of the *Antestia* must at times have had more than one hundred triungulins on them) only two became stylopised, one containing four larvae and the other one. Possibility of error (i.e. that triungulins might have been accidentally attached to the *Antestia* before they became adult, and have entered in the normal manner at an ecdysis) was precluded by the fact that the larvae (one male and four females) were alive when the hosts were dissected. If they had penetrated even at the final ecdysis they would have become adult long before.

(4) THE PARASITIC LARVA.

After penetrating a host the triungulins do not immediately moult, as other species of Strepsiptera are said to do (Pierce, 1909). At least up to 36 hours after penetration they are unchanged in appearance and, if dissected from their host, still active. Between two and three days after having penetrated

they swell considerably and the intersegmental membranes of the abdomen become readily visible, as they are in embryos shortly before hatching (fig. 19).

(a) *The first parasitic stadium.*

The first ecdysis takes place about three days after entry (when the average temperature is about 23° C.). This period is prolonged to at least six days in cooler weather (19°–20° C.). The great majority of triungulins that have succeeded in entering a host are also successful in undergoing the first ecdysis. Occasionally, however, a dead unmoulted triungulin has been found within the body cavity.

It will, of course, be readily understood that such information as is given on the intermediate stages of *Corioxenos* has been obtained by the examination of hosts that have been killed, or have died, a known number of days after the entry of the triungulin. Since the time of entry is in every case known to within a day, and since some 200 stylised *Antestia* have been examined with the sole view of tracing the development of the parasite, the estimated times for the duration of the several stadia are unlikely to be seriously in error.

On several occasions I have dissected, in Ringer's solution, a host when a contained triungulin was on the point of undergoing ecdysis. The head splits dorsally from the prothorax but remains hinged on the ventral side; the thoracic and abdominal segments do not split, though the intersegmental membranes of the latter are greatly distended—as they have been for about a day previous to the ecdysis. The first parasitic instar larva then wriggles its way out of the exuviae; the process from the time the head-capsule has become semi-detached until the larva is free takes about five to ten minutes. For some little time after the larva has got clear it continues wriggling actively.

It is a little difficult to be certain when larvae that have undergone the first moult in the thorax, as most of them do, migrate to the abdomen of their host. I think that in any case they do not do so early in the first parasitic stadium, since the few very young larvae that may be found in the abdomen can probably be accounted for by the (comparatively) few triungulins that directly penetrate the abdomen. Larvae that have nearly completed the first parasitic stadium are also not infrequently found in the thoracic cavity but, at least when a host contains only a small number of parasites, only seldom are larvae of the second parasitic instar to be found there. It is therefore presumed that the migration normally, though possibly with many exceptions, takes place towards the end of the first stadium. If, however, there are a very large number of *Corioxenos* in one host, those larvae that are unable to find room in the abdomen are quite capable of developing in the thorax, on rare occasions even up to the point when they should normally be exserted through the tergum of the abdomen. But it is probable that such larvae originally moved into the abdomen during their first stadium and were subsequently pushed back into the thoracic cavity by force of competition.

(b) *The later parasitic stadia.*

The precise method of ecdysis of the later instars is somewhat uncertain but, judging from the few larvae that I have been fortunate enough to find in the act, the old skin, which for some time previously has become completely detached from the new instar larva (fig. 28), is ruptured transversely towards the anterior end. The larva then wriggles out from the old skin of the abdomen as from a bag. Male larvae that have just moulted to the sixth parasitic instar have been

found completely free of the abdominal exuviae but with the exuviae of the head still adhering.

Before extrusion of the cephalothorax the young larvae are to be found in any position in the abdomen of the host and occasionally, as already stated, in the thoracic cavity. Their head may be pointed to either end of the host, less commonly they lie transversely. All the parasitic instars can make slight movements, which, in the later stages, appear to be facilitated by the dorsal prominences.

The earlier instars, at least, almost certainly feed entirely by diffusion * through the skin. Larvae of the later instars can be seen to make frequent movements with their rudimentary mouth-parts, but whether these play any part in nourishment is uncertain. I have failed to keep larvae, removed from their host, alive in nutrient solutions.

(c) *Duration of the stadia.*

The approximate average duration of the stadia during the warmer season (December to March) at Amani, when the temperature in the laboratory ranged from a maximum of 24° – 26° C. to a minimum of 20° – 22° C. is shown in Table 13.

TABLE 13.

Duration of the parasitic stadia of *Corioxenos*.

Number of days after entry of triungulins until ecdysis to	Males	Females
2nd (1st parasitic) instar	3 (a)	3 (a)
3rd (2nd parasitic) instar	10-12	10-12
4th (3rd parasitic) instar	16-20	15-17
5th (4th parasitic) instar	24-26	20-22
6th (5th parasitic) instar	28-30	24-26
7th (6th parasitic) instar	30-32	27-28
Extrusion of seventh instar from host (b)	33-35	28-32
Pupa	40-44	—
Adult	52-55 (c)	34-36 (d)

Notes :—

(a) Possibly slightly less, but known to be more than 60 hours.

(b) That is, supposing that the host has by this time become adult. If it has not, extrusion is of necessity delayed. In such cases of enforced delay extrusion can probably take place immediately the host moults to the adult instar, and certainly within 36 hours of its doing so.

(c) The shortest time actually recorded, under the conditions stated, was 50 days.

(d) Judged by when the female is capable of being fertilised by a male. The shortest time actually recorded, in a single instance only, was 31 days.

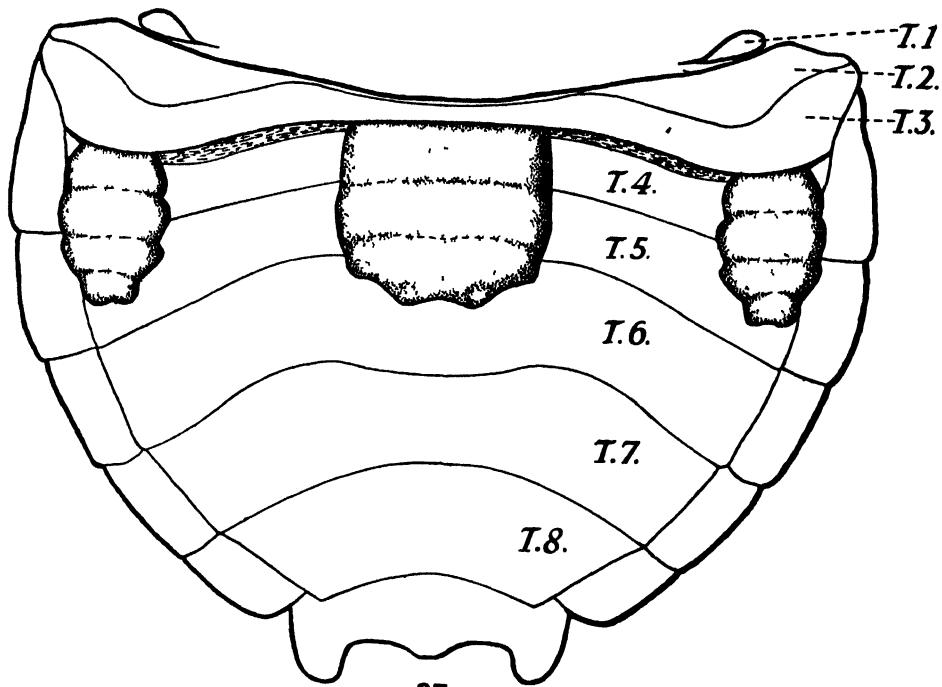
(d) *Extrusion of the cephalothorax.*

The cephalothorax of both sexes is invariably extruded through the inter-segmental membrane between the third and fourth † abdominal tergites (fig. 35).

* The term osmosis, which has frequently been used for this method of alimentation, is incorrect.

† I.e. as stated by Blair (1936), between the apparent first and second tergites. The first tergite is a very small and easily overlooked sclerite, and the second and third are more or less fused together.

No exception to this rule has been found in over 2500 stylopised hosts examined. The mature larva lies ventral side upwards within the body of the host, the extruded cephalothorax is bent backwards and lies in close apposition to the dorsum of the host's abdomen, its dorsal side is therefore uppermost.



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FIG. 35.—Diagram of the abdomen of *Antestia*, showing the position of extruded *Corioxenos* (one male and two females).

Without exception the females are extruded close to the pleura of the host. In the few instances in which a third female has become extruded in one host it has sometimes been found to overlap one of the others, and sometimes to lie parallel, but nevertheless as close to the side as possible.

The cephalothorax of the male is almost always extruded as near the middle as possible, even when the host contains no females, which would have pre-occupied the outside positions. Occasionally, where two males are present, one (probably the first to be extruded) is in the exact centre, and the other then necessarily somewhat to one side. Where there are three or more, one or two of them may occupy a place as near the pleuron as that usually occupied by a female, though sometimes, in their endeavour to avoid the side positions, two or more of them may overlap.

It is clear that the instinct of the female to choose the side positions is essential for the survival of the species; if they did not they could never be fertilised. It appears less necessary for the male to choose the centre, though the fact that it does so ensures that a female that may have entered at a later ecdysis of the host will still find a place for extrusion, even though one or two males, having entered at an earlier ecdysis, are already extruded. The number and sexes of the extruded *Corioxenos* contained in 2000 hosts are given in Tables 19 and 20 (Section 8).

(5) THE ADULT MALE.

(a) *Emergence from the pupa.*

The males emerge from the pupae during the morning, always between one and a half and seven hours after sunrise, and the great majority between two and four hours after. They tend to emerge earlier on bright sunny mornings than on dull days; similarly emergences were found to take place at an earlier hour on a verandah facing the east, and in a greenhouse exposed to the morning sun, than in the laboratory. It also appears (though I have not sufficient data to say that it is proved) that emergence can be delayed for at least one, and possibly two or even three days, if the mornings are heavily overcast. I have repeatedly observed that during a succession of two or three sunless mornings very few males emerge. But on the first bright morning many will appear, the triungulins of which had penetrated their hosts (kept under identical conditions) during a period stretching over at least three days. However, the length of time from the entry of a triungulin to the emergence of an adult may (as is discussed below) occasionally vary by as much as four or five days in the same host, so that it would need a very large number of observations to prove whether or not emergence is delayed by dull weather. No instance has been recorded of a male emerging later than 13h. 30 (and only a single and possibly doubtful case of one emerging after 12h. 45), even when a dull morning has been followed by a sunny afternoon. This appears somewhat remarkable, seeing that it is almost certain that the stimulus that causes the male to emerge must be light, even though the amount of light penetrating under the scutellum of an *Antestia* cannot be large. Not only do the facts already related tend to show that light is the necessary stimulus, but I made an experiment in which five hosts, known to be likely to produce adult males within a few days, were kept in complete darkness from 06h. 30 until 19h. 00, and from 19h. 00 until 06h. 30 were illuminated by electric light. All the six males produced by these hosts emerged between 21h. 30 and 24h. 00. (As they were not watched all night, it is just possible that some may have emerged after midnight, but since they were all quite dead by 06h. 30 on the following day, they could not have emerged much later.)

In the apparatus used for the foregoing experiment the temperature rose a few degrees when the light was turned on in the evening. Normally, of course, there is also a rise in temperature after sunrise, it might therefore be thought that it was the rise in temperature, rather than light, which stimulated emergence.

Seeing however that (1) emergences—even though comparatively few—have been observed on dull mornings when there has been no rise in temperature; (2) they were, as a rule, slightly earlier on a verandah facing the east than in a room facing west, although the temperature was higher in the latter than in the former; (3) in a greenhouse exposed to the morning sun, in which the morning rise in temperature was both large (7°–10° C.) and rapid, the males tended to emerge only a little earlier than on the cool but equally bright east-facing verandah, it seems probable that a rise in temperature is not the necessary stimulus.

A few males have been observed to emerge successfully from a host that had died on the preceding day. I extracted one from its pupal integument, contained in a host that had just died. It survived for 24 hours and was then found to be fully active and capable of fertilising several females.

During the ten to fifteen minutes before the male actually gets free from its
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host, the latter usually becomes agitated, walking rapidly a short distance, and then stopping to fan its wings as if preparatory to flight. The process of emergence takes as a rule some minutes, and the head and thorax of the partly freed male can be seen, during one of the periodical wing-movements of the host, appearing from under the tip of the scutellum. As has been explained, the pupa lies ventral side uppermost within the abdomen of the host, so that the male, emerging through the bent-over cephalothorax of its larval skin, comes out with its feet on the dorsum of the abdomen and facing the posterior end of the host.

When the male is nearly free, the *Antestia* frequently assists the process by pushing it out with its posterior legs; though the treatment thus given often appears to be rough, I have never observed that a male has been injured by it.

If there are more males than one in a host sometimes they all emerge almost together at intervals of not more than five minutes, or there may be an interval of an hour or slightly more; while not infrequently they emerge on different days.

Table 14 shows, for a total of 200 *Antestia* bred individually in the laboratory, from which two or more male *Corioxenos* emerged, the number of days, if any, elapsing between the emergences.

Expressed in a different manner, when two or more males emerged from one host (having entered it together, at the same ecdysis) in 39% of the cases they emerged on the same day; in 27% emergences were spread over two days; in 15% over three days; in 10.5% over four days; in 5% over five days; in 3% over six days, and in 0.5% over seven days.

The table does not include four instances from which it was clear from the number of days (13-18) elapsing between emergences, that the triungulins had

TABLE 14.

The number of days, if any, elapsing between the emergence of two or more male *Corioxenos* contained in the same host.

Two males	Three males	Four males	Five males
xx (64)	xxx (12)	xxxx (1)	xxxxx (1)
x1x (39)	x1xx (7) xx1x (7)	xxx1x (1)	
x2x (17)	x1x1x (4) x2xx (3) xx2x (3)	xxx2x (1) xx1x1x (1) x1xx1x (1)	
x3x (17)	x1x2x (2) x2x1x (2)		
x4x (7)	x1x3x (1)	xxx4x (1) x1x1x2x (1)	
x5x (4)	x4x1x (1) x5xx (1)		
	x1x5x (1)		

x indicates the emergence of a male.

The figure, if any, between two x's is the interval in days between emergences.
The figure in brackets is the number of instances recorded.

entered at different ecdyses of the host. For it is quite possible for a host to produce two males, the triungulins of which had penetrated at different ecdyses, in which case (conditions of temperature being equal) they emerge at an interval approximating to the interval between the two ecdyses. And though it has not been observed, there is no reason to suppose that a host could not produce three or even four males, which, as triungulins, had penetrated one each at the second, third, fourth and fifth ecdyses of the host.

As soon as a host is rid of its emerging male parasite it usually becomes calm and often starts feeding at once.

The male is capable of flight and copulation immediately after getting clear of its host. I have in fact more than once watched a male that did not leave the *Antestia* from which it emerged, but at once started copulating with a female *Corioxenos* in the same host.

(b) *Flight.*

The method of flight of male Strepsiptera has often been described as a series of rapid darts (Pierce, 1909). I suspect that this is because they have chiefly been observed in a small cage, in which case the above description is also true of this species. But if they are in the open, they fly quite steadily and slowly, with the body held almost vertically. This method of flight has been recorded by Muir (1906) observing *Elenchoides perkinsi* Pierce (*Elenchus tenuicornis* Muir nec Kirby).

If let loose in a room they tend to fly upwards, though they often come down again. As a rule they fly towards a source of light, but their positive phototropism is not very well-marked.

It is difficult to follow their movements when they are flying about among coffee bushes, and I have almost immediately lost sight of most of those I have watched, but they appear to hover among the branches in a manner reminiscent of Pipunculid flies. If confined in a small space, however, between the rapid darting flights of short duration, they walk about the bottom or sides of the cage, though even when walking the wings are kept in almost constant motion. At times, especially perhaps when about to pounce on the back of an *Antestia*, they make a distinct buzzing sound, how produced I have been unable to discover. When flying steadily in the open they are quite silent. Pierce (1909) has recorded that *Xenos (Acroschismus) pallidus* Brues buzzes during the whole of its active life, and that the noise is made by the elytra. This is almost certainly not so with *Corioxenos*, which appears, at least while copulating and I think also when flying, to keep its elytra practically motionless, and held nearly vertically upwards.

The active life of the male lasts only for two to three hours. Usually after about two hours they are incapable of copulating, and after at most three hours incapable of sustained flight. I have, however, observed one male that repeatedly copulated with two females in one host during a period of three hours and a quarter. It was then offered another stylopised *Antestia*, and immediately mounted it and penetrated the contained female which it successfully fertilised. At three hours and twenty-five minutes after emergence this male, though still active, would not copulate again. The foregoing appears, however, to be quite exceptional, and as a rule about three hours after emergence they are at most capable of a slow dragging walk in which the antennae and aedeagus are used to aid their now feeble legs. Although when confined in a cage they will show traces of life, by a slight twitching of the legs, up to six or seven hours after emergence, in the field they presumably never live for long after they have lost the power of

flight. If they are denied access to a female they live no longer than when they have spent the whole of their active life in intermittent copulation.

In a small cage, owing to their erratic and apparently aimless method of flight, they very easily become entangled in any moisture, such as the excreta of *Antestia*, that may be present. Having once got their wings wet, they are incapable of either further flight or of copulating. Judging, however, from their mode of flight in the open, it is probable that the premature mortality from such causes is actually much less than one would be led to expect from observations of the numbers that get thus entangled in a cage. I have been unable to observe what happens to an adult male during a shower of rain.

Natural enemies of the adult males are probably of little importance. Doubtless predaceous insects may account for a few, but the only observation made is of a single individual found caught in a spider's web.

(c) *Copulation.*

Exactly how the male is attracted to the female for the purpose of copulation is a question of considerable interest and is at present unsolved. Muir (1906) observing *Elenchoides perkinsi* arrived at the conclusion that sight was the sense by which the male found the female. To some extent my own observations confirm this, but it must be remembered that the female *Corioxenos* is usually entirely concealed, for as a rule it is only when there are also two or more males in the same host (and by the time these are exserted the females present may very likely already have been fertilised) that a female is so much pushed towards the side that it is partly visible. If therefore the male is attracted by sight, it is attracted to the host, and not to the female of its own species. This possibility is supported by the fact that a male will mount on the back of an *Antestia* that is not stylopised. Although it usually gets off again within a second or two, I have often seen one remain as long as a minute on an unstylopised *Antestia*, clinging on to the scutellum and tapping with its extended aedeagus all round the edges of the hemi-elytra, and also—though less frequently—other parts of the *Antestia* such as the head, prothorax and apices of the wings. I have also observed them to mount, though never for more than a few seconds, immature *Antestia* (which never have exserted females) and even other species of PENTATOMIDAE, and on one occasion a Cassidid beetle.

In some experiments made with a view to observing the exact method of copulation, I amputated the wings of a number of stylopised *Antestia*, so as to expose the extruded female parasites. When the wings on both sides were removed, copulation never took place; although a large number of males was introduced to *Antestia* thus treated, none mounted for more than a few seconds. When, however, *Antestia* were chosen that only had one extruded female, and the wings on the other side were left intact, copulation was observed in a few instances, though many of the males introduced would not perform the act. I suggest that this may be an indication that an unusual appearance of the host inhibits sexual attraction. On the other hand, males will copulate readily with females contained in *Antestia faceta*, which to us has a general appearance distinct from that of *lineaticollis*. They will not, however, copulate with females contained in *Antestia trivialis*, which in colour and general appearance is entirely different from *lineaticollis*. (See also Part III, Section 9.)

An experiment intended to ascertain whether the antennae of the male played any part in its search for a female was unsuccessful; it is obviously impossible to amputate the antennae of such an active insect without lightly anaesthetising it, and none so treated recovered properly from any anaesthetic

used, whether their antennae were amputated or not. (For the same reason it was not possible to experiment with males of which the eyes had been covered with an opaque substance.)

I think, however, that the sense of smell cannot play an important part in the search for a female, in view of the fact that a male quickly found, and mounted for a few seconds, an *Antestia* that had been soaked for five minutes in ether, and—at least to my olfactory sense—retained none of the typical Pentatomid smell. No males ever actually copulated with females contained in *Antestia* thus treated, which is perhaps hardly surprising, although I have often seen males copulate with females—probably still living—contained in hosts that had recently died.

Also, for what it is worth, it may be mentioned that males, enclosed in an empty box one half of the blotting-paper bottom of which had been rubbed over with squashed *Antestia*, were not noticeably attracted to that half.

I have several times dissected a live female *Corioxenos* (though how long it remained alive is difficult to say) from its host, covered its abdomen (which being moist would be liable to entangle the wings of the male) with a thin dry membrane and then offered it to a male. Copulation never took place with females extracted from their host, nor did any male show the slightest interest in them.

If the foregoing observations are correctly interpreted, *i.e.* if the sense of smell does not help the male to find a female, it is difficult to suggest what the function of the elaborate antennae of Strepsiptera may be. During the search for a female and during copulation the three branches of the antennae seem to be held wider apart than at other times, but they are not apparently brought into contact with the host.

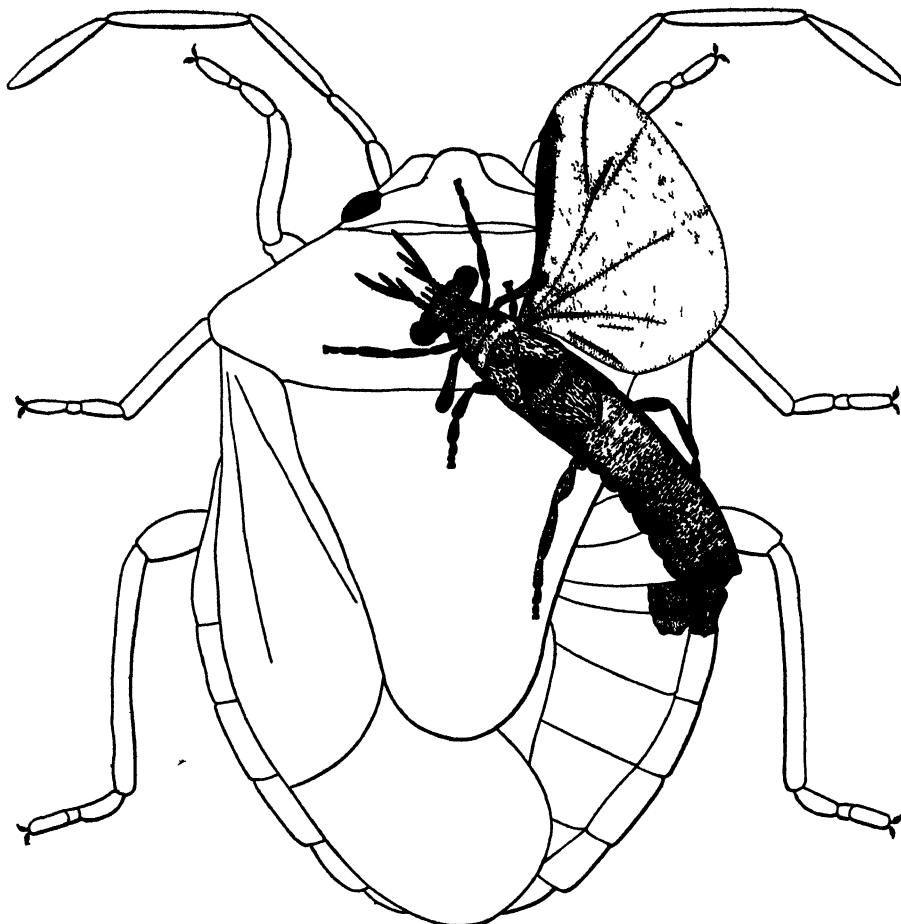
Males, confined only with unstyloped *Antestia*, will sometimes mount them repeatedly during the whole of their active life. (I have recorded three cases in which a male was put with an *Antestia* which it was thought might contain a female *Corioxenos*, apparent penetration of the male's aedeagus under the wing of the *Antestia* was observed, yet on subsequent examination no parasite, of either sex, was found.) At other times I have observed that after one or a few preliminary investigations a male will take no further interest, and occasionally, even from the first, it will take no notice whatever of an unstyloped *Antestia*.

A male, which had previously been proved to be sexually potent, was enclosed in a small box with an *Antestia* containing two females, both of which were adult, and kept for two hours in complete darkness. It failed to fertilise either of the females.

It appears therefore that the male is attracted in the first place by sight, but to the host, not to its own female; having found a host it finds the female of its own species by touch—*i.e.* by tapping with its aedeagus. Should this be correct, and no other explanation appears to fit the repeatedly observed facts, it is difficult even to speculate on the manner in which such an instinct has been evolved.

The actual method of copulation is as follows. When a male finds an *Antestia* containing an extruded adult female, it mounts on its back—usually approaching it from behind—and grasps with its feet the thorax and scutellum. Sometimes it makes one or more circular movements, tapping all the while the sides and even the head and abdomen of the *Antestia* with its extended aedeagus—as they frequently do when they have found an unstyloped *Antestia*. Often, however, penetration of the female is effected

almost immediately, within perhaps one second of the male having mounted. The position adopted during copulation is shown in fig. 36.*



36

FIG. 36.—*Corioxenos* in the act of copulating. $\times 12$.

For short intervals during the act of penetration the wings are held flat and motionless, between times they are kept in the usual constant movement; the position of the feet may be shifted slightly without the penis becoming disengaged.

The hosts are nearly always agitated when mounted by a male *Corioxenos* and walk about rapidly. Frequently they try, sometimes with success, to

* This figure is semi-schematic, though drawn from freshly killed specimens with the aid of a camera lucida. The *Anteoxia* is only depicted in outline, and the wings on the right-hand side are not shown, so that the position of the female parasite may be seen. The left wing of the male *Corioxenos* has been omitted.

dislodge the male by pushing it off with their posterior legs. It is remarkable that, although I have watched the process of copulation several hundred times, I have never once seen a host attempt to get rid of the male by the simple expedient of fanning its wings. Sometimes, especially perhaps when the female is a virgin and the "window" has to be pierced, the male makes several jabs with its aedeagus before securing penetration. But often penetration, even of virgins, is obtained at the first attempt. The duration of copulation is from a few seconds to upwards of a minute. On two or three occasions I have seen a male, apparently unable to free itself, remain *in copula* for nearly five minutes.

If the male is confined with a single host containing a female, it usually dismounts after copulation for a period varying between fifteen seconds and five minutes or more, subsequently mounting and copulating again at irregular intervals during the whole of its active life. If there are two females in the one host, the male will frequently copulate with both before dismounting.

The number of females that one male is capable of fertilising can only be guessed at, but is probably large. The most that I have recorded is 12, each of which was allowed access to the male for about two minutes, and all of which subsequently produced triungulins. Having fertilised these, it was still quite active, but no more females were available. Another male fertilised ten females in ten minutes, but was then unfortunately allowed to escape. There seems to be no reason why a single male should not be capable of fertilising a large number of females, provided, of course, that the concentration of hosts containing them is so dense that the male is able to find them during the course of its active life. On the other hand, I have several times observed a male that, although active and in no way damaged, appeared to be impotent and to take no notice at all of *Antestia* containing adult female parasites. Yet the testes of one of these apparently impotent males were full of active spermatozoa.

There appears to be no correlation between the duration of copulation and the number of triungulins produced. When penetration was deliberately interrupted after 5, 10 and 15 seconds, the female produced apparently as many young as when the male was allowed access to the female for the whole of its life. Similarly a female penetrated by a male eight times, but never for more than two seconds at each time, was completely fertile. Nor do three or four copulations (naturally by different males) at intervals of about seven to ten days appear to increase the number of young produced. The largest number of triungulins actually counted, produced by a single female, was 3720 spread over a period of 95 days (Table 15) and this was also the result of a single fertilisation.

Males will apparently copulate with females of any age—except during the first few days after they have become exserted, when they are still immature (Section 6 (b)). One male was observed to penetrate a female that had originally been fertilised some four months before, had been producing triungulins for two months, and of which the host died of old age a week later.

(6) THE ADULT FEMALE.

(a) *Extrusion.*

Under normal laboratory conditions during the warm season at Amani, the female larva extrudes its cephalothorax about 28–30 days after it has,

as a triungulin, entered its host. That is, of course, assuming that the host has itself become adult by this time, for in no circumstances do *Corioxenos* of either sex become exserted from an immature *Antestia*. If the triungulin has entered at the first or second ecdysis, or if, as sometimes happens, the later stadia of the host should be prolonged for more than the normal period, the last-instar larva is quite capable of remaining alive, entirely concealed within the host's abdomen, until the final ecdysis enables it to extrude its cephalothorax. Even with triungulins that have penetrated at the first ecdysis, such enforced delay before extrusion is not usually (*i.e.* apart from delayed development of the host) more than about fifteen days, and it is known, from instances in which the development of the host has been delayed, that the larvae are able to remain alive for at least twice the normal period without becoming extruded.

It seldom happens (see also Tables 19, 20) that more than two females in one host can become extruded. When, however, several female larvae are present, those that fail to extrude not infrequently develop to the adult instar. It is not known accurately how long such totally enclosed adult females remain alive, but those which have (probably) been adult for a month or more always appear to be dead, and their gut is congested with opaque excremental matter.

Out of 1000 hosts bred separately in the laboratory 185 contained more than two adult female *Corioxenos*. One hundred and sixty-four of these had two extruded females and from one to six adult but unextruded. In only 21 was a third female extruded. The extrusion of four females has never been recorded.

When two females do succeed in becoming extruded on one side of the host their cephalothoraxes may either overlap, or, more often, they lie parallel. Two instances were recorded in which both the females on one side were fertilised; in one of these the second female was, when the host was examined, lying on the inner side of the other. It is, however, hardly possible that it could have been reached by the aedeagus of the male when in this position, so presumably it was overlapping the other female when it was fertilised, and subsequently became pushed to the inside position.

It is also possible for females to become adult, and males to develop to the pupal instar, entirely within the body of an immature *Antestia*. I have only seldom recorded this, but it is of sufficient interest to give one instance in detail. Five triungulins were put on to a third-instar *Antestia* on 3.iii.36. The host moulted to the fourth instar on 6.iii, and to the fifth on 19.iii. It died without having become adult on 25.iv, *i.e.*, it had remained in the fifth stadium for 37 days, or at least 23 days longer than the normal period at that time of the year. On dissection it was found to contain two male pupae, one adult female (which was in the thoracic cavity), and one fully developed female larva. The females were still alive when the hosts were dissected, though no sign of life could be seen in the male pupae.

(b) *Fertilisation.*

After extrusion of its cephalothorax a period elapses before the female has become adult and is capable of being fertilised. As the only means of ascertaining the length of this period is by introducing a male, if one is available, every day to a female that has recently become exserted, and noting whether it copulated, and if so was successful in fertilising the female, I have been unable to collect many data on this question. The shortest period recorded (once only) between the entry of a triungulin and the fertilisation of the female it produced, is 31 days. I have also one record of 32, one of 33, and several of 34

days. A male had been introduced to each of these females on the previous day and, though it had mounted the host and apparently shown considerable interest, it had not actually copulated. Since 27 days is the shortest time recorded for the period from the entry of the triungulin to the extrusion of the female larva, it appears that a female is adult and capable of being fertilised four days after it has extruded its cephalothorax, though about seven days is probably more usual.

The period for which a female remains capable of being fertilised is surprisingly long. One female to which no male had access until 119 days after it had, as a triungulin, entered its host, was then successfully fertilised. This was in the cool season, when development is slower, but since females in other hosts kept under the same conditions at the same time of the year were fertilised within 46 days from the time of their entry, it appears that the period during which a female can be fertilised may extend to some ten weeks. Copulation has frequently been observed with much older females, but has not resulted in fertilisation, apparently on account of the eggs having degenerated.

It may be remarked that Perkins (1918), observing *Stylops wilkella* Perkins, thought that the females were only attractive to the males for a very short period, and that if they were not fertilised during this period they reproduced parthenogenetically, but this is certainly not true of *Corioxenos*.

Copulation nearly always appears to succeed in fertilising a female of suitable age; I have recorded only a few fertilised females that failed to produce triungulins—provided of course that the host lived long enough—and in most of these the fungus *Penicillium* sp. had gained access through the empty puparium of a male and had also attacked the female. (Part III, Section 6.)

I have found no indication that parthenogenesis ever occurs, but have amassed a considerable amount of evidence to show that it does not. Over 200 hosts containing only female *Corioxenos* have been kept singly until they died, no male parasite allowed access to them. None of these produced triungulins and, at least in females that had been adult for three months or more, the eggs appeared to have degenerated.

The proportion of females that succeed in becoming fertilised under field conditions is probably very large. Unfortunately in the earlier field counts (Part III, Section 7, Table 30) I neglected to distinguish between fertilised and unfertilised females.

In the counts made from December 1935 onwards, I recorded the percentage of females that were either parturient or contained well-developed eggs. It varied between 55% and 74% with an average of 67.5%. Many of the remainder would certainly have been recently fertilised, but time did not allow the examination of large numbers sufficiently closely to see if the "window" on the outer side of the cephalothorax had been pierced. I estimate that all those fertilised less than three weeks before capture were therefore not included and that the percentage actually fertilised would not have been less than 80.

Since the developmental period of the female is much shorter than that of the male (Table 13) a female is, under field conditions, likely to have already been fertilised before a male contained in the same host has emerged. As all the *Corioxenos* in one host would often, though not of necessity, be siblings, interbreeding is thus to a large extent avoided. Whether this is of any importance in the economy of the species is not known; in any case, females have, in the laboratory, been successfully fertilised by males bred in the same host, and known to have had the same parents.

(c) *Incubation period of the eggs.*

The period of incubation, from the time of fertilisation to the emergence of the first triungulins, is about six weeks during the warm season at Amani, and considerably more during the cooler time of the year (Section 7). The egg stage therefore lasts longer than all the subsequent developmental stages of the female and nearly as long as those of the male. Apart from insects that have a diapause in the egg stage (a phenomenon, so far as I know, rare among tropical insects) such a division of the developmental period is very unusual. It is presumably accounted for by the advanced state of development attained by the triungulins at the time of eclosion.

(d) *Production of triungulins.*

The period during which a fertilised female continues to produce triungulins is apparently determined only by the length of life of the host. Of 150 parturient female *Corioxenos*, the hosts of which were kept separately under observation in the laboratory, the only ones that ceased to produce triungulins before the death of the host were a few attacked by the fungus *Penicillium* sp. The host of these all died within a few days of the cessation of the production of triungulins.

The longest time for which a female *Corioxenos*, under laboratory conditions, has been known to produce triungulins is 95 days, and by good fortune this was one of the few of which the daily production of triungulins was accurately counted (Table 15). This female had only been fertilised once. Though I have often allowed males to fertilise the same female several times at intervals of a few days, it cannot be said whether this might result in an extended period of fecundity, since none of the hosts of these females lived as long as 95 days after first producing triungulins. There are no indications that more than one fertilisation increases the rate at which triungulins are produced.

I have found no trace of a spermatheca in the female. Several females, dissected at varying intervals up to about 14 days (in one instance 17) after they had been fertilised, had free active spermatozoa, usually in enormous numbers, in the body cavity. But in none of the females examined more than 18 days after copulation could I find a single live spermatozoon. It therefore seems certain that fertilisation of the eggs must be accomplished within at most

TABLE 15.

The average number of triungulins produced daily by five individual female *Corioxenos*.

	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	13th week	14th week	After death of host	Actual total	
1	25	60	57	55	52	34	34	host died on 49th day.								not counted	2220
2	86	63	61	38	26	19	(2 days) 20	host died on 44th day.								60	1800
3	83	87	48	42	36	33	85	27	42	51	35	30	16	(4 days) 14 host died on 95th day	184	3790	
4	12	29	(4 days) 50	host died on 18th day.											90	570	
5	8	29	(6 days) 43	host died on 20th day.											198	715	

about 17 days after copulation, yet it is known that the embryos may arrive at maturity over a period of 13 weeks. The eggs on the periphery are known to be the first to mature, a possible explanation of which, suggested by Cooper (1937), is that they may receive more abundant nourishment. As these hatch, the eggs originally in the interior become pushed outwards where their development is accelerated. Table 15 shows the average number, and actual total, of triungulins produced daily by five hosts each containing one fertilised female *Corioxenos*. Since it was found impossible to count accurately the number adhering externally to the host, or to remove them from the host, the figures given are not actually of the triungulins that emerged daily, but of those that left their maternal host, up to about 16h. 30 each day.

TABLE 16.

The length of adult life of *Antestia* containing parturient female *Corioxenos*.

		Number of instances	Total adult life (days)			Duration of life after first starting to produce triungulins		
			average	maximum	minimum	average	maximum	minimum
♂ hosts	With 1 fertilised ♀ <i>Corioxenos</i>	37	102	157	52	20	95	1
	With 2 fertilised ♀ <i>Corioxenos</i>	33	88	125	53	12	39	1
♀ hosts	With 1 fertilised ♀ <i>Corioxenos</i>	33	110	165	53	30	58	3
	With 2 fertilised ♀ <i>Corioxenos</i>	47	98	152	60	24	85	1

TABLE 17.

The period of development of male *Corioxenos*, from the entry of the triungulin to the emergence of the adult.

Month of emergence	In laboratory						On verandah of laboratory					
	No. of Emergences	Max. period	Min. period	Av. period	Mean temp. during av. period	Mean range of temp.	No. of emergences	Max. period	Min. period	Av. period	Mean temp. during av. period	Mean range of temp.
1935												
Nov.	45	86	66	74	20.8	2.8	—	—	—	—	—	—
Dec.	58	74	59	65	22.1	2.7	18	67	57	60	21.2	5.7
1936												
Jan.	43	59	53	57	23.3	2.5	30	62	54	57	22.7	5.9
Feb.	7	68	53	55	23.5	2.4	13	64	53	57	22.8	5.8
March	31	60	51	53	23.7	2.3	58	61	50	54	23.1	5.7
April	19	56	51	53	23.5	2.4	22	59	51	54	23.0	5.2
May	32	64	53	58	22.7	2.0	20	66	56	62	21.7	4.0
June	8	67	62	64	21.6	1.7	8	75	69	71	20.4	3.2
July	3	78	74	76	21.0	1.8	21	89	78	81	19.7	3.3
Aug.	21	86	74	77	20.3	2.0	10	93	84	89	19.2	3.3
Sep.	27	85	75	78	20.2	2.4	47	92	83	86	19.0	3.4
Oct.	84	84	73	77	20.4	2.7	28	94	76	82	19.6	3.9

Temperatures are given in ° C.

Table 16 shows the average time for which parturient hosts, kept in the laboratory, survived after first starting to produce triungulins. A fair average estimate is, therefore, that one female *Corioxenos* will produce about 50 triungulins a day for 20 days, under laboratory conditions. It is probable that in the field the duration of fecundity is somewhat longer, since many of the hosts kept in the laboratory became infected with *Penicillium* and therefore died prematurely. This fungus has been found in stylopised hosts collected in coffee plantations, but not in any large proportion of them. Moreover, when parturient hosts are kept in small containers in the laboratory it often happens that very large numbers of *Corioxenos* of the second generation start to develop in them (see also Section 3). This undoubtedly hastens the death of the host more than under natural conditions.

(7) THE INFLUENCE OF TEMPERATURE ON THE DURATION OF THE LIFE-CYCLE.

Most of the information under this head is derived from data on the developmental period of the male, and on the time elapsing between fertilisation of the female and the appearance of the triungulin larvae, under different conditions

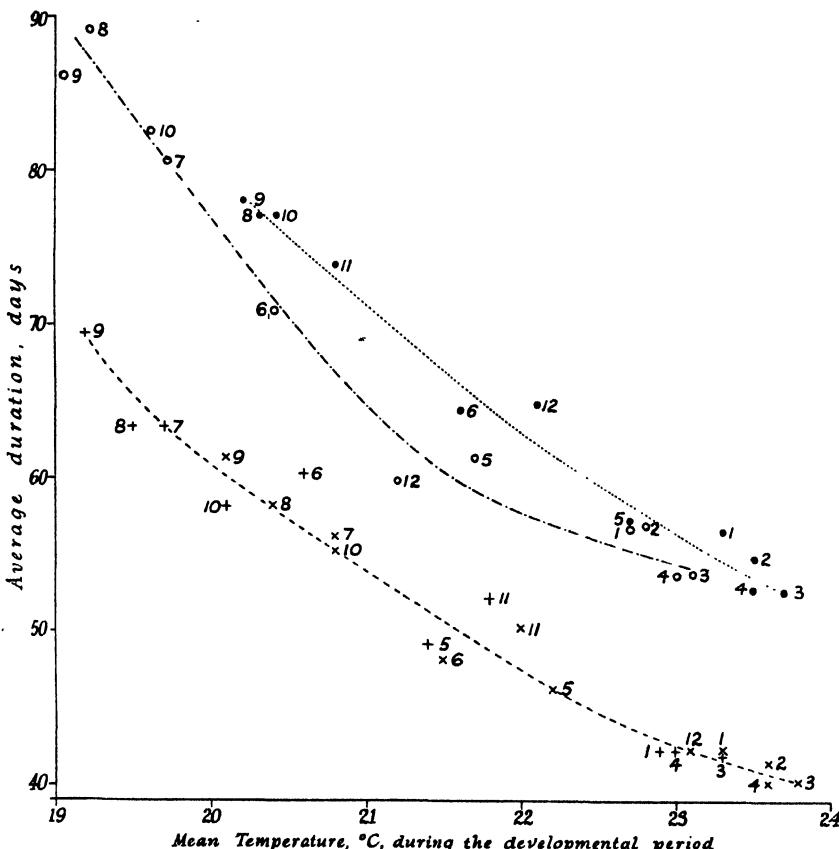


FIG. 37.—The period of development of *Corioxenos* in relation to the temperature.

of temperature. These are the only two periods in the life-cycle of *Corioxenos* that can be determined with exactitude without killing the host. Table 17 shows the maximum, minimum and average period of development of 596 males, according to the month in which they emerged; the mean temperature and the mean range of temperature during the average period of development is also given. Of these males 326 emerged from hosts kept in the laboratory, where the range of temperature was small. The remaining 270 were from hosts kept on an enclosed verandah, where the mean temperature was slightly lower than in the laboratory, but the range considerably greater.

It is at once apparent that quite a small difference in temperature has a large effect on the length of the development period. Thus those emerging in the laboratory in March had taken on the average 53 days, during which period the mean temperature was 23.7°. Those emerging in September had averaged 78 days, or nearly 50% longer, though the mean temperature during those 78 days was only 3.5° lower.

These results are also shown graphically in fig. 37, from which it will be seen that, for a given mean temperature, development tended to be rather quicker on the verandah than in the laboratory. The temperature on the verandah was more variable, with higher maxima and lower minima, and this may be the cause of the slight acceleration.

I have made only a few experiments in an incubator at approximately constant temperatures, the following data being obtained. At 28.7°, 49 days (a single male only); at 26.0°, 50 days; at 25.0°, 49–50 days; at 24.5°, 50 days; at 22.8°, 57–59 days. These are rather longer periods than one would expect from an extrapolation of the curves in fig. 37, which may also be an indication that a too constant temperature has a retarding effect on development. If this is so, it does not apply to the development of the eggs, the curve for which is also shown in fig. 37.

Table 18 shows the time required for the development of the eggs, from

TABLE 18.

The incubation period of *Corioxenos*, from fertilisation until the appearance of the first triungulin larvae.

Month triungulins appeared	In laboratory			On verandah		
	No. of instances	Av. incubation period (days)	Mean temp. during incubation period (° C.)	No. of instances	Av. incubation period (days)	Mean temp. during incubation period (° C.)
1935.						
December	6	42	23.1	—	—	—
1936.						
January	7	42	23.3	5	42	22.9
February	5	41	23.6	—	—	—
March	3	40	23.8	3	42	23.3
April	13	40	23.6	10	42	23.0
May	7	46	22.2	7	49	21.4
June	7	48	21.5	1	60	20.6
July	8	56	20.8	1	63	19.7
August	2	58	20.4	1	63	19.5
September	4	61	20.1	4	69	19.2
October	13	55	20.8	2	58	20.1
November	14	50	22.0	14	52	21.8

fertilisation until the appearance of the first triungulins, during different months of the year. Since it is based on only 137 hosts containing fertilised females, of which 89 were kept in the laboratory and 48 on the verandah, the numbers for some of the months are necessarily small. However, the very great influence of comparatively slight temperature changes is clearly seen. Thus, both in the laboratory and on the verandah, the incubation period of eggs hatching during November was ten days longer than that of eggs hatching during April, yet the difference in the mean temperature during the two incubation periods was only 1.6° in the laboratory and 1.2° on the verandah.

The shortest period recorded for the development of the eggs is 34 days, in an incubator at a temperature almost constant between 24.5° and 25.0°.

Data on the developmental period of the female during the cool season are somewhat scanty, owing to there not always being a male available with which to ascertain whether a female had actually become adult or not. However, during July and August, the mean temperature being about 20.5°, no female was fertilised less than 45 days after it had, as a triungulin, entered its host. This compares with 31–34 days when the mean temperature was about 23.5°.

In general it can be deduced from the foregoing data that between the limits of about 23.5° and 19.5°, a drop of 4.0° in the mean temperature increases the life-cycle by 60%, of 3.5° by 50%, of 3.0° by 40%, of 2.5° by 33%, and of 1.5° by 15%.

(8) THE PROPORTION OF THE SEXES.

Tables 19 and 20 show the number and sex of the extruded *Corioxenos* found in each one of 1000 stylopised *Antestia* collected in coffee plantations, and bred in the laboratory, respectively.

Nearly 50% of the hosts collected in the field had only one extruded parasite; the maximum number found, in fourteen hosts only, was five. The total number in the 1000 hosts was 1858. Of the parasites 42.6% were males, this proportion being virtually identical in both male and female hosts.

The sex ratio of the extruded *Corioxenos* in hosts bred in the laboratory is slightly different, for the following reasons. Many of these hosts had had more triungulins placed on them than could possibly find room to become extruded, and the total number of extruded parasites (2626) is considerably greater than that in the hosts stylopised under natural conditions. Five extruded parasites were found in 55 hosts, six in 8, and seven (the maximum number recorded) in 2.

Since it is an uncommon occurrence for more than two females to become extruded in one host (Section 6) whereas three or four males may frequently do so (I have twice recorded five and once six), it is clear that the greater the average number of parasites per host, the higher the proportion of males will be. Table 21, based on the same data, shows how the proportion of males tends to rise according to the number of parasites that become extruded.

There is some tendency, apparent both in the collected and the bred hosts, for the higher numbers of parasites, four or more, to be more frequent in female than in male hosts. This is no doubt explained by the slightly greater size of female *Antestia*. Consequently when the rate of parasitism is high there will be a slight tendency for female hosts to produce a greater proportion of male *Corioxenos*, as is evident from Table 20, but apart from this the sex of the parasite is not in any way influenced by the sex of the host.

TABLE 19.
The number of extruded *Corioxenous*, and the proportion of the sexes, found in 1000 stylised *A. lineaticollis* collected in the field.

No. and sex of extruded <i>Corioxenous</i>	1 ♂	1 ♀	2 ♂	1 ♂ + 1 ♀	2 ♀	3 ♂	2 ♂ + 1 ♀	3 ♂ + 1 ♀	2 ♂ + 2 ♀	3 ♀ + 1 ♀	3 ♂ + 2 ♀	1 ♂ + 3 ♀	2 ♂ + 3 ♀	1 ♂ + 2 ♀	3 ♂ + 2 ♀	5 ♂ + 3 ♀	3 ♂ + 2 ♀	2 ♂ + 3 ♀	Total no. of <i>Corioxenous</i> ♂♂	Total no. of <i>Corioxenous</i> ♀♀	Total no. of ♀
♂ hosts	73	123	15	45	48	5	25	28	3	4	12	1	1	3	—	—	—	386	292	42.8	
% with parasite	1																		390	390	57.2
♀ hosts	114	167	23	63	80	10	36	63	6	4	33	5	—	9	1	—	—	—	—	—	—
% with parasite	1																		—	—	—
Total hosts	187	290	38	108	128	15	61	91	9	8	45	6	1	12	1	—	—	—	—	—	—
% with parasite	1																		—	—	—

TABLE 20.
The number of extruded *Corioxenous*, and the proportion of the sexes, found in 1000 stylised *A. lineaticollis* bred in the laboratory.

No. and sex of extruded <i>Corioxenous</i>	1 ♂	1 ♀	2 ♂	1 ♂ + 1 ♀	2 ♀	3 ♂	2 ♂ + 1 ♀	3 ♂ + 2 ♀	1 ♀	3 ♂ + 2 ♀	2 ♂ + 1 ♀	4 ♂ + 1 ♀	3 ♂ + 2 ♀	2 ♂ + 1 ♀	5 ♂ + 3 ♀	4 ♂ + 2 ♀	6 ♂ + 1 ♀	6 ♂ + 2 ♀	Total no. of <i>Corioxenous</i> ♂♂	Total no. of <i>Corioxenous</i> ♀♀	Total no. of ♀
♂ hosts	34	63	22	63	76	14	46	68	6	1	17	54	2	3	13	1	1	3	1	—	—
% with parasite	1																		—	—	—
♀ hosts	43	45	23	61	74	17	38	65	6	2	30	62	4	11	25	2	—	4	—	1	—
% with parasite	1																		—	—	—
Total hosts	77	108	45	124	149	31	84	133	12	3	47	116	6	14	38	3	1	7	1	1	—
% with parasite	1																		—	—	—

TABLE 21.

The proportion of sexes of extruded *Corioxenos*, according to the number that developed in each host.

No. of extruded <i>Corioxenos</i> per host	No. of hosts	No. of ♂ <i>Corioxenos</i>	= % ♂♂	No. of ♀ <i>Corioxenos</i>	= % ♀♀
(a) Collected in the field (1000)					
1	477	187	39.2	290	60.8
2	274	184	33.6	364	66.4
3	176	258	48.8	270	51.2
4	59	120	50.9	116	49.1
5	14	43	(61.4)	27	(38.6)
(b) Bred in the laboratory (1000).					
1	185	77	41.6	108	58.4
2	318	214	33.6	422	66.4
3	260	394	50.5	386	49.5
4	172	391	56.8	297	43.2
5	55	176	64.0	99	36.0
6	8	33	(68.8)	15	(31.2)
7	2	13	(81.3)	3	(18.7)

PART III.

THE RELATION BETWEEN *ANTESTIA* AND *CORIOXENOS*.

(1) EXTERNAL SIGNS OF STYLOPISTION.

Certain species of Hymenoptera, when stylopised, differ in their external characters very noticeably from unstylopised specimens, so much so that Imms (1934) has stated that "much confusion has consequently arisen through the founding of new species on stylopised individuals." As a rule males tend to assume the secondary sexual characters of females and *vice versa*.

Antestia suffer no such effects when parasitised by *Corioxenos*. Except in the terminal segments of the abdomen there is no sexual dimorphism in *Antestia*. Males are, however, on the average rather smaller than females. But the larger males equal or exceed in size the smaller females.

Measurements were made of (a) the length of the scutellum, (b) the breadth of the head across the eyes, of 40 unstylopised and 40 stylopised individuals of each sex of *A. lineaticollis*. All the 160 bugs thus measured had been bred under similar conditions in the laboratory and fed on the same food—full-sized but still green coffee berries. Measurements are given in units of an eye-piece micrometer, one unit being equal to 0.0476 mm. Table 22 compares the two sexes of unstylopised bugs. The sex difference in size is clearly significant, the value for measurement (a) being over twelve times, and for measurement (b) about nine times its standard error.

Tables 23 and 24 compare the males and females respectively of stylopised and unstylopised bugs. The reduction in size of males, consequent upon

TABLE 22.

The difference in size between the sexes of unstyloped *Antestia*.

	♂♂	♀♀	Difference between means	Standard error of difference
(a) Mean length of scutellum	66.2	73.3	7.1	± 0.577
Variance	5.85	7.46		
Variance of the mean . .	0.146	0.187		
(b) Mean breadth of head .	47.5	49.9	2.4	± 0.272
Variance	1.64	1.31		
Variance of the mean . .	0.041	0.033		

TABLE 23.

The difference in size between unstyloped and styloped males.

	Unstyloped	Styloped	Difference between means	Standard error of difference
(a) Mean length of scutellum	66.2	65.0	1.2	± 0.562
Variance	5.85	6.80		
Variance of the mean . .	0.146	0.170		
(b) Mean breadth of head .	47.5	46.8	0.7	± 0.307
Variance	1.64	2.13		
Variance of the mean . .	0.041	0.053		

TABLE 24.

The difference in size between unstyloped and styloped females.

	Unstyloped	Styloped	Difference between means	Standard error of difference
(a) Mean length of scutellum	73.3	70.0	3.3	± 0.715
Variance	7.46	12.97		
Variance of the mean . .	0.187	0.324		
(b) Mean breadth of head .	49.9	48.4	1.5	± 0.345
Variance	1.31	3.435		
Variance of the mean . .	0.033	0.086		

stylopisation, is suggestive of a real effect but is not necessarily significant, since for measurement (a) the difference between the means is scarcely twice the standard error, and for measurement (b) only a little more than twice. There can, however, be no doubt that stylopisation tends to reduce the size of females, since for both measurements the difference between the means is some four times the standard error.

This small reduction in size, although of theoretical interest, is of no value in determining whether an individual is stylopised or not. Stylopisation does not affect the coloration. It is, therefore, often impossible to tell from external examination whether an *Antestia* is stylopised. It is always impossible with immature *Antestia*, in which no external signs of stylopisation can be seen. (The point of entry of the triungulin is not, after a few hours, visible even by microscopic examination.) In adult *Antestia* also, provided that stylopisation is not excessive, say not more than one male and two females in a host, it is usually impossible to detect the presence of the parasite by superficial examination. The male puparia, at least if only one or two are present, are entirely hidden under the scutellum, and the females are usually so well concealed under the wings that they are invisible even when the host is viewed from the side with a lens. Sometimes, however, particularly when two or more males are also present, a female is so much pushed out to the side that the margin of its cephalothorax is readily visible. Also when a host contains two, three, or more males, its wings may not lie in close apposition to the dorsum of the abdomen, and any contained females are then, if not conspicuous, at any rate just visible.

If a male host contains a large number of *Corioxenos*, and especially if it has one or two parturient females, its aedeagus remains permanently extended. This, however, is not a very reliable indication of stylopisation since I have seen a few unstylopised males in the same condition. Very heavily stylopised individuals are rather more sluggish and find some difficulty in flying, although one containing two male puparia and two adult (not fertilised) females was able to fly in an apparently normal manner.

(2) INTERNAL EFFECTS OF STYLOPISTION.

Since the presence of *Corioxenos* shortens the life of *Antestia* only a little (Section 3), it is clear that no serious injury can be done to the internal organs. Moreover, the method by which the parasite feeds, by diffusion on the blood of the host, does not cause any structural damage. Even when an *Antestia* is stylopised at an early stage, all the organs develop in an apparently normal manner and, with the exception of the sexual organs, actually function normally. The alimentary canal may be pushed far out of its natural position, but it is unimpaired in efficiency. It may even have more work to do, since I suspect, though I have not proved, that stylopised *Antestia* feed more than unstylopised ones.

The actual effect on the sexual organs is, however, very great. With few exceptions the ovarioles of a stylopised *A. lineaticollis* (fig. 38) never produce mature eggs. Out of over 600 females bred in the laboratory, only five, each with a single *Corioxenos* that had entered at the final ecdysis, contained from five to thirteen apparently mature eggs. I also have a very few records of females collected in the field, each with only one parasite, that contained a few eggs in their ovaries. But I have never known a stylopised female *A.*

lineaticollis to oviposit, even when it had had access to an unstyloped male with which it had copulated.

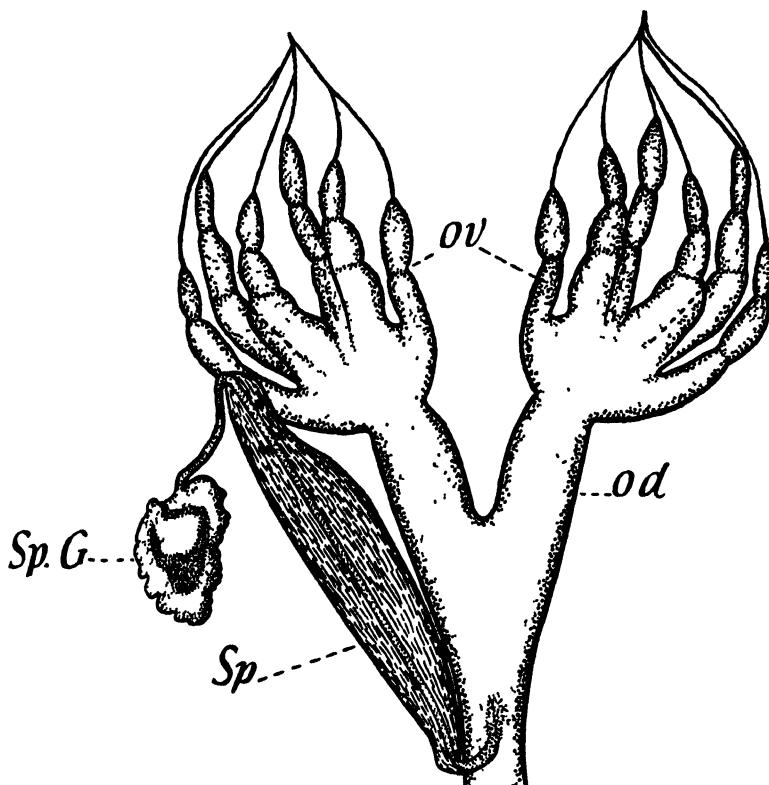
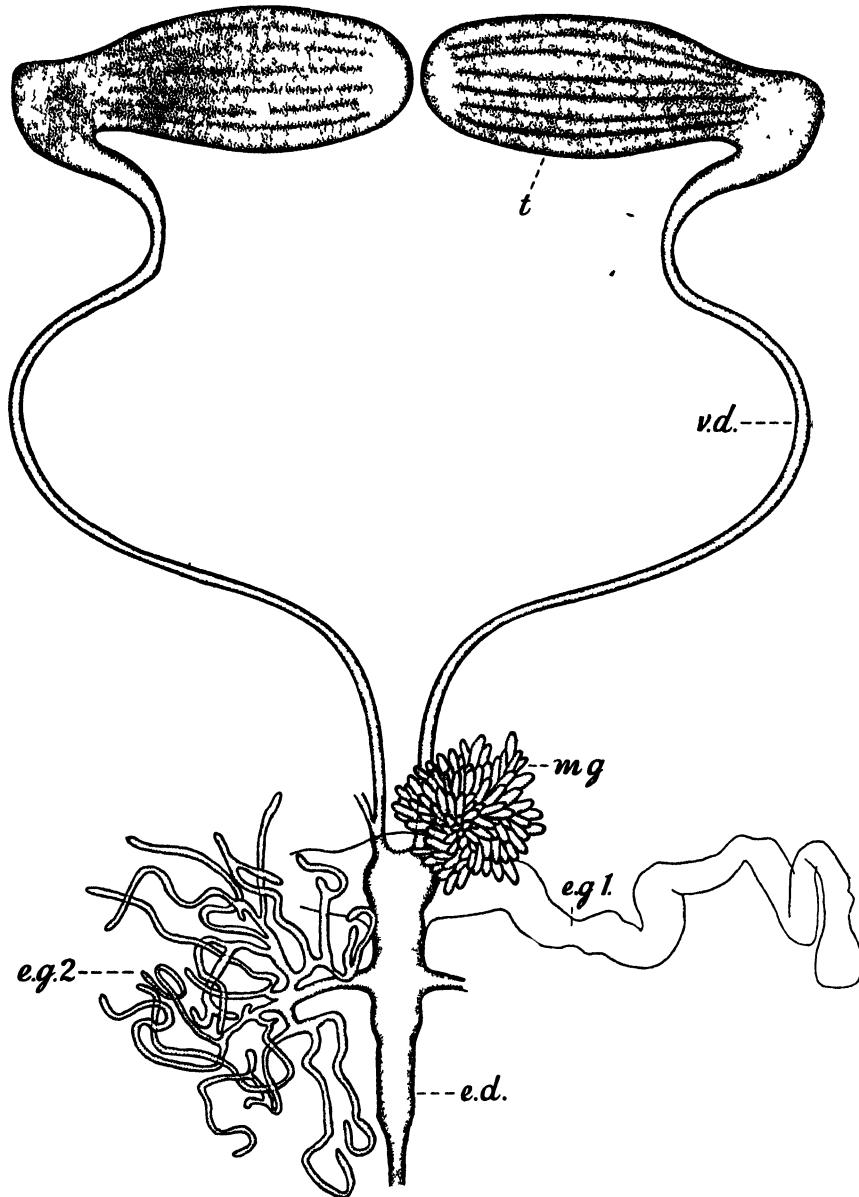


FIG. 38.—*A. lineaticollis*. Reproductive organs of female (styloped). $\times 20$.

Styloped females are, therefore, invariably infertile. So also, as a rule, are styloped males, though there are exceptions to this when the male did not become styloped until either the fifth or adult instar. Thirty unstyloped virgin females were enclosed in one cage with twenty males which had become styloped at the third or fourth instar. Copulation was observed on several occasions, but although about 85 egg batches were laid, no single egg hatched.

Table 25 shows the results of 20 experiments in which an unstyloped virgin female was kept separately with a styloped male, from the time the latter became adult. (It should be mentioned that pairs of unstyloped *Antestia* kept under the same conditions have invariably produced from ten to twenty batches of fertile eggs. Most often all the eggs hatch, only seldom has more than one egg of a batch proved infertile. Unfertilised females usually lay from two to four batches, and then cease ovipositing.)

It will be seen that although several of the males that had not become styloped until the fifth or adult instar were to some extent fertile, none of the females fertilised by them laid a normal number of viable eggs.

FIG. 39.—*A. lineaticollis*. Reproductive organs of male (unstyloped). $\times 19$.

The reason why styloped males should be infertile, apart from the exceptions detailed in Table 25, is obscure. I have examined the testes of a large number, including several with three or four extruded parasites which had entered at an early ecdysis; active spermatozoa, apparently indis-

tinguishable from those produced by unstyloped males, were always abundant. Moreover, styloped males readily copulate; I have seen one do so five hours after three male *Corioxenos* had emerged from it. Careful examination has revealed no difference in either the size of the testes or in the accessory glands of styloped males. Fig. 39 shows the genital organs of an unstyloped male *A. lineaticollis*, but the figure would do equally well for one containing several *Corioxenos*. The functions of the accessory genital glands of PENTATOMIDAE are not known, and it is possible that, although they appear to be unimpaired, their secretions are somehow affected by stylopisation.

TABLE 25.

The fertility of eggs laid by unstyloped female *Antestia* which had been paired with styloped males.

No. and sex of the <i>Corioxenos</i> in the ♂ <i>Antestia</i>	Instar at which they entered	No. of egg batches laid by the female	No. of eggs that proved fertile
2 ♀♀	Third	3	none
2 ♂♂, 1 ♀	Fourth	3	none
1 ♂, 3 ♀♀	"	2	none
1 ♂, 1 ♀	"	2	none
3 ♂♂, 2 ♀♀	Fifth	2	none
3 ♂♂, 1 ♀	"	4	none
1 ♂, 2 ♀♀	"	2	none
1 ♂, 2 ♀♀	"	1	none
1 ♂, 1 ♀	"	3	none
1 ♀	"	2	none
2 ♂♂, 1 ♀	"	5	all of first three batches
1 ♂, 1 ♀	"	2	all of first batch
2 ♀♀	"	3	two eggs of first batch
1 ♀	"	4	all of first batch
1 ♂, 1 ♀	Adult	3	none
2 ♀♀	"	3	none
3 ♂♂	"	4	a single egg of first batch
1 ♂	"	7	all the first six batches
1 ♂	"	6	all
1 ♂	"	4	all the first three batches

(3) THE EFFECT OF STYLOPISTION ON THE DURATION OF THE STADIA AND ON THE LENGTH OF ADULT LIFE.

A comparison of the duration of the fourth and fifth stadia was made with 23 unstyloped *Antestia* and 23 that had become styloped at the third ecdysis; all other conditions were similar. No difference was found, the aggregate number of days spent in the fourth stadium by the 23 nymphs being 311 for the unstyloped and 314 for the styloped. In the fifth stadium it was 401 and 400 respectively.

Stylopisation does, however, tend to reduce the duration of adult life, though not so much as in some other hosts of Strepsiptera (Pierce, 1909).

Table 26 shows the average and maximum duration of adult life of 415 *Antestia*, according to the number of *Corioxenos* (including those that failed to become extruded) contained in each host. Though it is clear that excessive stylopisation does reduce longevity, yet some individual hosts containing

several parasites have survived for a period much longer than the average life of unstylopised *Antestia*.

Although many hosts of Strepsiptera die soon after the emergence of the male parasite (Perkins, 1905; Pierce, 1909) this is not so with *Corioxenos*, except perhaps when the empty puparium becomes infected with *Penicillium* (Section 6). Table 27 shows the average length of life of 350 hosts after the emergence from them of male *Corioxenos*. If the emergence of males tended to shorten the life of the host, it would be expected that there would be a close correlation between the number of males that emerged and the subsequent length of the host's life. But this is not so, except perhaps when four or five males were produced by one host.

It is, however, probable that the presence of parturient female *Corioxenos* may have some effect in hastening the death of the host, since for both sexes of the host those with two parturient females lived on the average a shorter time than those with only one (Table 16 in Part II, Section 6). The fact that the average duration of life of these stylopised *Antestia* was almost identical with that of unstylopised ones does not necessarily refute this supposition, since only those hosts which are reasonably long lived will survive long enough to produce parturient female *Corioxenos*.

It is remarkable that the presence of such a large parasite as *Corioxenos* should have such a small effect on the longevity of its host. It may be that any debility caused by stylopisation is compensated by the resulting inactivity of the sexual organs.

TABLE 26.

The average duration (in days) of adult life, according to the number of *Corioxenos* (whether extruded or not) contained in each host.

No. of <i>Corioxenos</i> per host	Male hosts			Female hosts		
	Instances	Av.	Max.	Instances	Av.	Max.
0	20	98	197	30	121	245
1-2	41	94	322	48	100	234
3-4	77	70	202	88	78	162
5-6	44	54	169	50	70	188
7-13	8	29	57	9	67	167

TABLE 27.

The average time of survival (in days) of 350 hosts after the emergence of male *Corioxenos*.

No. of ♂ <i>Corioxenos</i>	Male hosts			Female hosts		
	Instances	Av.	Max.	Instances	Av.	Max.
1	72	53	281	98	56	195
2	58	48	150	65	55	127
3	12	51	165	33	47	110
4	1	—	33	10	35	79
5	1	—	32	—	—	—

(4) PREMATURE MORTALITY OF NYMPHAL HOSTS.

When breeding unstyloped *Antestia* in the laboratory, provided that they are fed on full-sized but still green berries (Part I, Section 3), there is very little mortality among nymphs, at any rate after the second ecdysis and apart from the comparatively few deaths clearly due to an imperfect and usually delayed ecdysis. Some of the few recorded deaths, not connected with an imperfect ecdysis, were probably due to injuries accidentally caused while changing the food.

When, therefore, styloped *Antestia* have died before becoming adult, it is reasonable to assume that stylopisation has most often been the cause of death. This is, however, not a common occurrence, as is shown from the following few cases out of the many hundred styloped nymphs that have been successfully bred to maturity in the laboratory.

(a) Three instances only of the contained parasite larvae, not so far developed as to extrude normally even if their host had become adult, rupturing the host's abdomen at the time of its ecdysis. *E.g.* Six triungulins penetrated a nymph at its second ecdysis on 11.xii.35; the third ecdysis took place on 23.xii and the fourth was begun on 4.i.36, but before the exuviae were completely shed some of the six larvae (which were in the fourth and fifth parasitic instars) had ruptured the abdomen of the host under the scutellum. The host died almost immediately.

(b) Two instances only in which death may have been due to some of the parasite larvae remaining in the thorax. In one of these a fifth-instar nymph died and was found to have two fifth-instar larvae in its thorax as well as five in its abdomen; in the other there were three fourth- and fifth-instar larvae in the thorax and four in the abdomen.

(c) Sometimes excessive parasitism undoubtedly causes the death of the nymph. Thus if six or more triungulins penetrate at the second ecdysis, or fifteen or more at the third, the host usually does not survive to become adult.

Experimentally, of course, when a given number of triungulins are placed on a nymph of one of the earlier instars, it would be easy to obtain numerous premature deaths from super-parasitism. Under natural conditions, judging from the numbers of larvae contained in styloped nymphs collected in the field, premature mortality from this cause is very uncommon.

Occasionally, when a stadium of the host—usually the fifth—is unduly prolonged, the contained female parasites have arrived at maturity and (once only) a male parasite has become a pupa, while still entirely within the host's abdomen. These hosts failed to become adult. Since, however, excessive delay in moulting in itself often, though not invariably, results in the death of the nymph, it cannot be said with certainty that stylopisation has caused the death of these nymphs. Moreover, when triungulins enter at an early ecdysis of the host, the resulting larvae are able successfully to postpone extrusion for several days, waiting until their host becomes adult.

(5) THE COMPARATIVE IMMUNITY FROM STYLOPISTION OF *ANTESTIA* WITH MALFORMED ANTENNAE.

Over 1000 *Antestia lineaticollis*, kept in separate containers and with a known number of triungulins placed on each, have been bred in the laboratory. Forty-nine of these had malformed antennae, the number of segments being less than the usual five, and often some or all of the segments short and

misshapen. Five such antennae, with a normal one for comparison, are shown in fig. 40. In many of these specimens both antennae were deformed, though not always to the same extent; in a few one antenna was almost or quite normal.

Antestia with deformed antennae do not appear to be abnormal in any other respect, except that there may be a tendency for the stadia to be prolonged. The duration of the fifth stadium of 20 such deformed *Antestia*

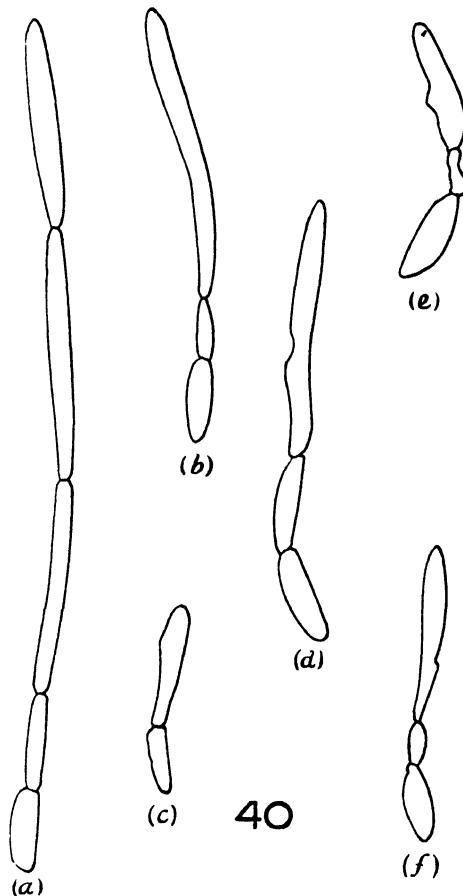


FIG. 40.—*A. lineaticollis*. Malformed antennae of individuals that failed to become stylopised. $\times 21$.

departed from the mean of this stadium in normal individuals, at the same time and under the same conditions, by + 16 days, + 14, + 12, + 7, + 6 (2), + 3, + 2, + 1 (3), ± 0 (6), - 1, - 2 (2). The mean duration of the fifth stadium of these deformed *Antestia* was 3.2 days longer than that of the normal ones, but this is not statistically significant. The difference in variability is, however, certainly significant, the value of z being more than twice the corresponding 1 per cent. value.

This deformity is not inherited and females with imperfect antennae,

whether mated with similar or with normal males, readily pair and produce offspring normal in every way, including susceptibility to stylopisation.

However, of the 49 *Antestia* so deformed, 41 failed to become stylopised, though in one of these a single triungulin had penetrated but failed to moult. A summary of these observations is given in Table 28. The eight exceptions

TABLE 28.

Antestia with abnormal antennae, that failed to become stylopised.

Next instar of the <i>Antestia</i>	No. of instances	Total no. of triungulins placed on nymphs	Av. no. of days until next ecdysis
Adult	6	52	11
Fifth	21	145	9
Fourth	11	69	6
Third	3	15	6

TABLE 29.

Antestia with abnormal antennae, that became stylopised.

Next instar of the <i>Antestia</i>	No. of instances	Total no. of triungulins placed on nymphs	Av. no. of days until next ecdysis	No. of triungulins penetrated and developed
Adult	1	10	11	1
Fifth	3	22	8	6
Fourth	4	22	3	11

are summarised in Table 29. Of these eight, five had only one malformed antennae and two of the three which had both malformed as nymphs, when the triungulins were placed on them, had grown very nearly normal antennae by the time they were adult. Moreover, the proportion of triungulins that succeeded in penetrating and developing in these eight hosts (18 out of 54) is distinctly lower than the average for normal hosts.

Seeing that out of 1000 normal potential hosts, treated in a precisely similar way, only 57 failed to become stylopised (Table 12 in Part II, Section 3), there is clearly a correlation between malformed antennae and immunity to stylopisation. It is possible that malformation of the antennae may be, at least usually, due to a difficult ecdysis. If so, this would support the hypothesis (Part II, Section 3) that the moult fluid, a deficiency of which might lead to a difficult ecdysis, is the stimulus that urges the triungulins to penetrate an *Antestia* that has just cast its skin.

(6) THE FUNGUS, *PENICILLIUM* SP., IN STYLOPISED *ANTESTIA*.

This fungus* is not infrequently found in hosts, bred in the laboratory, that contain an empty male puparium of *Corioxenos*. It cannot be considered an entomophagous fungus in the ordinary sense, being probably a saprophyte on *Corioxenos* and possibly a wound parasite on *Antestia*. Having gained access through a male puparium it will sometimes then attack any

* Determined by Dr. H. H. Storey, Plant Pathologist, East African Agricultural Research Station.

fertilised female in the same host; I have also twice recorded its attacking a fertilised female in a host in which no male puparium was present. In these two cases it had probably entered through the hole in the "window" of the cephalothorax, by which fertilisation had been effected. It is impossible to say whether these females were alive when attacked. I have never found it in hosts containing only un-emerged males or unfertilised females, nor in unstyloped *Antestia*.

I think that *Antestia* in which *Penicillium* has become established do not survive for long. It is difficult to be certain of this, since there are no external signs of the infection and the presence of the fungus can only be determined by dissecting the host. Most of the styloped *Antestia* (over 1000) that have been bred in the laboratory have been examined either just after they had died or when they were clearly on the point of death. It is suggestive that it is only in these that *Penicillium* has been found, and never in the comparatively few (of which about 30 contained empty male puparia and were therefore presumably liable to infection) that have been examined after having been killed while they were still apparently healthy.

I have recorded the length of life of 350 hosts after one or more male *Corioxenos* had emerged from them (Section 3, Table 27), but unfortunately did not always note whether *Penicillium* was present or not. I think, however, that it was more often present in the hosts that died comparatively early, and this would also be an indication that it accelerates the death of the host. Should this be so, it is certain that *Penicillium* has an adverse effect on *Corioxenos*. For though it does not matter how soon a host that has produced only males should die, many hosts that have already produced males, and are therefore liable to attack by the fungus, also contain fertilised females. Premature death of such hosts will therefore result in a reduction of the number of triungulins produced.

Perkins (1905) describing an apparently similar fungus attacking *Elenchoides* (*Elenchus*), a parasite of DELPHACIDAE, also concluded that it caused early mortality of the host. However, he was of the opinion that for this reason it was beneficial and that in any attempted introduction of *Elenchoides* the fungus should also be introduced. I am positive that the reverse is the case with the fungus attacking *Corioxenos*, though, since it is probably a species that is everywhere abundant, and since in any case fungus infection is much less usual in styloped *Antestia* found in the field than in those bred in the laboratory, it is unlikely to be of much importance.

(7) SEASONAL VARIATION IN THE PERCENTAGE OF STYLOPED *ANTESTIA* IN THE FIELD.

I have made several counts, at somewhat irregular intervals between February 1935 and October 1936, of the percentage of styloped *Antestia* collected in coffee plantations in the vicinity of Lyamungu. In these counts, which are summarised in Table 30, only adult *Antestia* were examined, and only those with extruded parasites were recorded as styloped. The figures given for the percentage of stylopisation are therefore rather lower than they should be, but time did not permit of making, with large numbers of *Antestia*, the careful dissections necessary to detect the presence of unextruded parasites.

The fluctuations are large, from 84% styloped in May 1935 to only 12% in December, with a rapid increase to 54% two months later.

It does not appear possible to correlate the recorded fluctuations with any weather conditions during the preceding few months, except that there may be a tendency for the rate of stylopisation to fall during the cool season. This would be expected, partly on account of the longer time required for the life-cycle and partly because the more sluggish habits of *Antestia* nymphs in cold weather may render them less likely to pick up triungulins. There seems to be no correlation whatever with rainfall. The highest rate of stylopisation (in May 1935) was after four wet months in which over 1500 mm. of rain fell, and the lowest (in December 1935) after five dry months in which the total fall was only 180 mm. Then, with the rainfall still below the average, the rate rose sharply, and it decreased again between June and August 1936, when the rains were exceptionally heavy and prolonged.

The high rate of parasitism in May 1935 can possibly be accounted for by the intensive spraying campaign (with arsenic bait spray) that had been carried out about two months previously, for I have shown (Part II, Section 3) that triungulins are able to emerge unaffected from maternal hosts that are dying of arsenic poisoning. For the rest the percentage of parasitism probably follows, with a time lag of about two months, the abundance of the host, in accordance with the law of Malthus (Muir, 1931).

TABLE 30.

Seasonal variation in the percentage of styloped *Antestia* in the Lyamungu district.

Month collected	Male hosts			Female hosts			Total hosts		
	No. examined	No. styloped	% styloped	No. examined	No. styloped	% styloped	No. examined	No. styloped	% styloped
1935.									
Feb.	270	136	50	442	225	51	712	361	51
May	31	25	81	44	38	86	75	63	84
Sep.	93	48	52	151	102	67	244	150	61
Dec.	159	22	14	195	19	10	354	41	12
1936.									
Feb.	26	17	65	35	15	43	61	32	52
June	46	26	55	65	27	42	111	53	48
Aug.	42	11	25	73	19	26	115	30	26
Oct.	38	14	37	27	8	30	65	22	34
Total of above	705	299	42	1032	453	44	1737	752	43

It will be seen from Table 30 that both sexes of the host are equally liable to be styloped, the percentage of females attacked being very slightly, but not significantly, higher than the percentage of males.

(8) THE VALUE OF *CORIOXENOS* AS A CONTROL OF *A. LINEATICOLLIS*.

It does not appear from the literature that any species of Strepsiptera has been recorded definitely as exercising much control over the numbers of its host. Theobald (1892) believed that stylopisation was the cause of extermination of some colonies of *Andrena lapponica* Zett. at St. Leonards, England, between 1886 and 1890. But other factors may also have been at work, including, as suggested by Pierce (1909), the zealous collecting done by Theobald himself.

Muir (1906) entertained great hopes that *Elenchooides perkinsi* Pierce (*Elenchus tenuicornis* Muir nec Kirby), which he found in Fiji parasitising *Perkinsiella vitiensis* Kirk., would be of value in controlling the allied Hawaiian cane leaf-hopper (*P. saccharicida* Kirk.). His expectation was not, however, fulfilled, since it refused to attack the latter species.

Tillyard (1926) states that in general Strepsipterous parasites of Homoptera are to be regarded as highly beneficial.

It is difficult to evaluate the part played by *Corioxenos* in the control of *Antestia* in the coffee plantations on the slopes of Kilimanjaro, for it is clear that it is not, in the accepted meaning of the phrase, exercising an efficient control. For, in spite of the high percentage of parasitism, *Antestia* is still a serious pest which frequently causes considerable loss to the coffee crop, unless artificial control measures are taken.

But a parasite is obviously to be regarded as valuable if, as Imms (1931) has stated, its presence results in the need for less frequent artificial control measures to secure the same degree of effective control. It seems inevitable that a parasite such as *Corioxenos*, which reduces the fecundity of its host by some 40 to 50 per cent., should produce this result. It could only be otherwise if its absence meant that one or more of the egg-parasites of *Antestia* would then increase to such an extent that they would destroy a sufficiently larger percentage of the greater number of eggs that would be laid. In theory a Strepsipterous parasite should work well in conjunction with an egg-parasite. For though the Strepsipteron will reduce the number of eggs laid and therefore, by decreasing the food supply, tend to reduce the population of egg-parasites, the latter are, more than most parasites, adept at searching for their potential hosts.

Perhaps the most valuable feature of *Corioxenos* is the manner in which it fits in with the arsenic bait spray consistently advocated by Ritchie (1932), and in Tanganyika used with conspicuous success. I have proved (Part II, Section 3) that the triungulins of *Corioxenos* can emerge unaffected from *Antestia* that are dying or even dead as a result of this bait spray. It is suggestive that after application of the bait on a plantation near Lyamungu the percentage of stylopisation rose rapidly (Section 7) and the *Antestia* population remained at a low level for several months. It is still more suggestive that in Kenya, where *Corioxenos* does not occur, the arsenic bait spray does not give consistently satisfactory results (LePelley, 1932, 1934), so that reliance has to be placed on an effective, but far more expensive, method of control (LePelley, 1933).

It is known (LePelley, 1932) that the arsenic spray destroys large numbers of Hymenopterous parasites, including the egg-parasites of *Antestia*. It therefore seems very likely that this spray is only thoroughly successful where, as in Tanganyika, the work of the egg-parasites is largely replaced by that of *Corioxenos*.

Whether *Corioxenos* could be successfully introduced into another part of East Africa remains to be proved. At first sight it might be thought almost useless to introduce a parasite from one part of a continent to another, on the grounds that if it could be established in the other part it would already have become so. But the mountains of Kilimanjaro and Meru, the only localities where *Corioxenos* occurs, are virtual islands, and their fauna, in many ways different from that of the surrounding country, can have had little opportunity of becoming dispersed.

Though I am not aware of any evidence as to the original home of

Antestia, species of which are found in most tropical regions, it seems unlikely that it is Kilimanjaro. On the other hand, since *Corioxenos* has only been found on Kilimanjaro and Meru, it is probable that it is indigenous to these localities, though it may perhaps only have taken to parasitising *Antestia* in comparatively recent times. Its absence from other areas in East Africa where *Antestia* is abundant is much more likely to be due to geographical barriers having prevented its dispersal than to climatic or other factors being unsuitable.

(9) STYLOPISTION OF OTHER SPECIES OF *ANTESTIA*.

(a) *Antestia faceta* Germ.

This species has occasionally been found naturally styloped in the Kilimanjaro district. Since, however, it is comparatively uncommon there, I have made insufficient counts to determine whether it is normally parasitised to the same extent as *A. lineaticollis*.

I have made only 38 laboratory experiments with individuals of this species kept separately, but these are sufficient to show that *Corioxenos* attacks *faceta* readily. The proportion of triungulins successful in penetrating at the third ecdysis, and then developing, seems, however, to be lower than in *lineaticollis*.

The information obtained is summarised in Table 31.

TABLE 31.
Stylopisation of *Antestia faceta*.

Next instar of potential host	No. of instances	No. of potential hosts that failed to become stylopised	No. of days from attachment of triungulins to next ecdysis of potential host (average)	Total no. of triungulins attached	Total no. that penetrated and developed
Adult	1	0	13	5	1
Fifth	23	2	8	119	72
Fourth	14	2	6	76	28

Owing perhaps to the smaller size of *faceta*, premature mortality due to stylopisation is of more frequent occurrence than with *lineaticollis*. However, of the 38 potential hosts with which experiments were made, 17 (9 males and 8 females) produced adult *Corioxenos* as follows:—Male hosts—1 male, 1; 1 female, 1; 2 males, 1; 1 male and 1 female, 3; 2 females, 1; 1 male and 2 females, 2. Female hosts—1 female, 3; 2 males, 1; 2 females, 2; 2 males and 1 female, 1; 3 females, 1.

It is also of interest that I have collected in the field a male *faceta* from which four male *Corioxenos* had already emerged.

Male *Corioxenos*, whether bred in *faceta* or *lineaticollis*, will readily fertilise females contained in *faceta*, though only one host survived long enough to produce triungulins, which it did over a period of 20 days before its death.

It is somewhat remarkable that the only two stylopised male *faceta* that have been put with unstylopised virgin females, proved to be potent. One

male containing one male and two female *Corioxenos*, fertilised a female which laid six batches of viable eggs. The other male contained four female parasites (two of which were not extruded) and successfully fertilised a female, which laid four batches of viable eggs. Both these males were seen to copulate within a few minutes of being put with the females. While no conclusions can be drawn from only two instances it is, considering the comparative rarity of a stylopised male of *A. lineaticollis* being potent (Section 2), at least possible that stylopisation has less effect on the male organs of *faceta*.

So far as the few records obtained show, the time required for the development of *Corioxenos*, of either sex, is the same in *faceta* as in *lineaticollis*.

The above facts indicate that *Corioxenos* would be unlikely to become established in *faceta*, where this is the only species of *Antestia* present. Where, however, *lineaticollis* and *faceta* occur together, there can be little doubt that the parasite reduces the reproduction rate of the latter species as well.

(b) *Antestia trivialis* Stål.

This species has not been recorded from the Kilimanjaro and Arusha districts and has, therefore, never been found naturally stylopised. I have found it in small numbers on arabica coffee in the East Usambaras and made the following few experiments and observations on its relations with *Corioxenos*.

Table 32 gives the results obtained from 31 nymphs kept individually in the laboratory.

TABLE 32.
Stylopisation of *Antestia trivialis*.

Next instar of potential host	No. of instances	No. of potential hosts that failed to become stylopised	No. of days from attachment of triungulins to next ecdysis of potential host (av.)	Total no. of triungulins attached	Total no. that penetrated and developed
Adult	3	2	9	Uncounted, but a very large number	11
Fifth	11	7	6	100	8
Fourth	11	9	7	87	5
Third	6	3	5	33	3

Thus of these 31 potential hosts only ten became stylopised at all, and of a total of about 300 triungulins which became attached to these potential hosts, only 27 penetrated and developed, 11 of these 27 being contained in a single host (which died prematurely). Of the remaining 16 only 7, 4 males and 3 females, arrived at maturity. The other 9 developed as far as the fifth or sixth parasitic instar but failed to become extruded and died.

Male *Corioxenos* were repeatedly introduced to the *trivialis* hosts known to contain the three extruded females, but they showed no more than a casual interest, mounting them only for a few seconds at a time and never attempting

to copulate. This is of some importance in connection with the views put forward in Part II, Section 5, concerning the sense that enables the male to find the female.

The four male *Corioxenos* that emerged from *trivialis* hosts were normal in every way, and readily copulated with females contained in *lineaticollis*.

Antestia trivialis is a larger insect than *lineaticollis* and, possibly for this reason, stylopisation seems to have less effect on the female genital organs. Three females from each of which one male *Corioxenos* had emerged, each laid a few egg batches. All the eggs were, however, infertile, although an unstylopised male had been introduced to each female and copulation had been observed. Another female, containing three female *Corioxenos* (only two extruded) was almost immediately mounted by an unstylopised male, and, though it did not oviposit, its ovaries contained fully formed eggs. Also the female in which eleven larvae developed to the fifth and sixth instars contained mature eggs in its ovaries, though none had been laid by the time of the death of the host.

The effect of stylopisation on the male organs of *trivialis* is not known, since none of the few males that became stylopised were put with unstylopised females.

It can, I think, be assumed that *trivialis* is not a normal host of *Corioxenos* and would never become naturally stylopised under field conditions. Even if, in a mixed population of *lineaticollis* and *trivialis*, a few of the latter were to be parasitised, the controlling influence of such casual parasitism could not be of any importance.

(c) *Antestia falsa* Schout.

I have only found this species in the South Paré mountains where, although *A. lineaticollis* is also abundant, *Corioxenos* does not occur. The following few laboratory experiments were made. In 20 nymphs of various instars, on which a total of 200 triungulins were placed, no *Corioxenos* larvae developed; although in three of them a few triungulins had penetrated but had failed to moult. These 20 nymphs all became adult and lived for a normal time. In 4 nymphs a total of 19 out of 45 triungulins penetrated and developed to the first or second parasitic instar, but their hosts died prematurely. One fifth-instar nymph on which 5 triungulins had been placed lived for a month after becoming adult; on its death it was found to contain a single third parasitic instar larva which had clearly died some time previous to the death of the host.

Thus of 250 triungulins placed on nymphs of this species only 20 developed at all, and only a single one as far as the third parasitic instar. It is therefore clear that *falsa* is not a normal host of *Corioxenos*. The reason is not known, for in size and general appearance *falsa* resembles *lineaticollis* more closely than *faceta* does.

No experiments have been made with *Antestia usambarica* Schout., of which I have so far only found a single female which failed to lay eggs.

Triungulins have been put on to nymphs of a number of other species of PENTATOMIDAE, but they never penetrated.

It can therefore be concluded that *Corioxenos antestiae* is a specific parasite of the genus *Antestia*, and under field conditions probably confined to the species *lineaticollis* and *faceta*.

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AN HISTORICAL STUDY OF THE MIGRATIONS OF *CELERIO LINEATA LINEATA* FAB. AND *CELERIO LINEATA LIVORNICA* ESP. (LEPIDOPTERA)

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[Read 5th May, 1937.]

SINCE early in 1931 the South-Eastern Union of Scientific Societies has been encouraging the collection of records dealing with the migration of insects in the British Isles, and a special Insect Immigration Committee has been set up to organise the efforts of amateurs and others who are interested in this branch of entomology. As a result of the Committee's activity, a great deal of useful information is collected yearly and sent to Rothamsted Experimental Station, where it is available for examination and analysis. Some very interesting facts and theories are already beginning to emerge from this steadily accumulating mass of data, but it suffers somewhat from the drawback of dealing only with current events, and many years must pass before one can expect by its means to throw much light on underlying problems such as periodicity, correlation with climatic factors, or the relationship between migrations in the British Isles and those in other parts of the world.

Another store of information is, however, available in all those periodicals and journals which have for a century or more been in the habit of devoting part of their space to records of the observations of collectors and naturalists in all parts of the world. From these it seemed that it might be worth while to make an investigation into the past history of one or two individual species for comparison with the more recent records of the Insect Immigration Committee.

In 1931 *C. lineata* var. *livornica* became unusually common in western Europe, and was reported to the Insect Immigration Committee in greater numbers than it had ever before been recorded in Great Britain. This led to its selection for the present investigation, and it has proved to be a very suitable subject in many ways. Not only is it rare enough in this country to have received a good deal of attention from collectors, but in other parts of the world its larvae are occasionally a pest of vines and other cultivated plants, and its years of unusual abundance have therefore been recorded from time to time in the economic literature. In addition, the information available is sufficiently abundant to provide an adequate basis for investigation, without being so copious as to prove unmanageable. In fact the species might almost have been designed to suit the purposes of the work in hand.

Distribution.

The moth generally known in this country as *Celerio* (*Deilephila*, *Phryxus*) *livornica* Esp. is the old-world sub-species of the Sphingid *Celerio lineata* Fab., the nominal form being confined to America. A third sub-species, *Celerio l. livornicoides* Lucas, is found in Australia, but so little is known about it, and it has so seldom been recorded in any abundance, that I do not feel justified in dealing with it here.

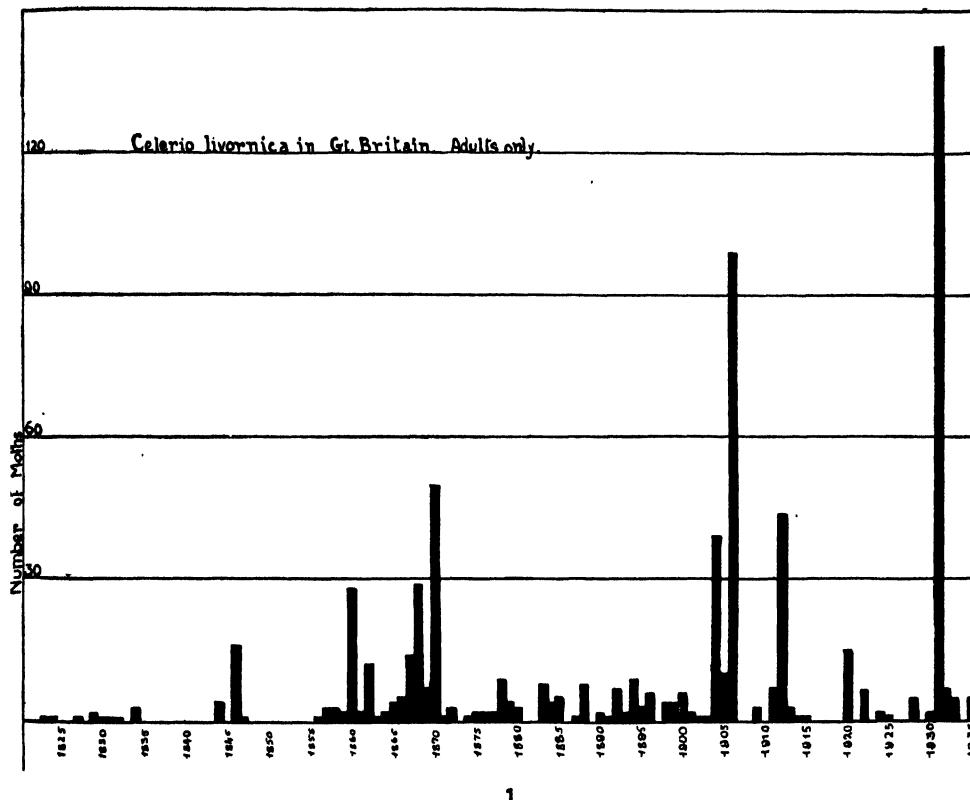
C. lineata and *C. l. livornica* are very similar both in appearance and habit, but they appear to form perfectly distinct geographical races, and there is sufficient difference in their markings and gross morphological detail to prevent their confusion when seen side by side. *C. lineata* has been seen from New Jersey to Ecuador, and *C. l. livornica* from China to western Europe and southward to the Orange Free State, yet in neither case is the permanent habitat (if any) known with any degree of certainty. In some of the warm-temperate parts of the northern hemisphere they have been seen frequently enough to give the casual observer the impression that they are indigenous, but a closer examination of the literature suggests that they are usually migrants from elsewhere. *C. l. livornica*, for example, is fairly frequently seen in the African littoral of the Mediterranean, and occasionally appears there in great abundance as a pest. Many years may pass, however, without a single record coming from this area, and when the larvae ravage the vineyards in years of abundance, the cultivators seem to regard them as an unusual pest. In various parts of Europe the moths have been abundant in about one-third of the past sixty years, and small numbers have occurred more often, yet the species has nowhere permanently established itself, and it may be absent for years on end. The same seems to be true of the American sub-species, which is common in some seasons in many parts of the United States, but can hardly be said with certainty to be indigenous in any particular district.

Outbreaks of both sub-species are most frequent and abundant in the neighbourhood of deserts and semi-desert areas; for example, California, Utah, Arizona and other States surrounding the Great American Desert; Morocco, Algiers and Tunis, near the Sahara; and Anatolia, the Caucasus, southern Russia, and Persia, near the deserts and arid steppes of Asia Minor. The only reference I have been able to find to an outbreak in South America took place in 1925 in the Santa Elena Peninsula, a desert district in Ecuador, during the first rains that had fallen for several years. One may perhaps venture to suggest that one is dealing with a desert species which, in response to unusual conditions of climate or to some similar stimulus, sometimes outbreeds the resources of its normal habitat, and is forced to migrate elsewhere. American entomologists would probably agree with this view, since they often find *lineata* especially common on the outskirts of deserts in its years of abnormal abundance. The habits of the larvae are quite compatible with this supposition. They occur on all sorts of low-growing plants and weeds, and not only the species but even individuals are extremely polyphagous. On several occasions it has been observed that when a large number of larvae have completely destroyed the food plants on which they were hatched, they will migrate gregariously, examining everything in their path, until they have found a sufficient growth of something suited to their taste; this may be a species belonging to a different family or even to a different natural order from that on which they started life. Behaviour such as this would have a definite survival value for a species dependent for its food supply upon the sparse flora of desert areas. An interesting account of such a mass migration of larvae is given by J. Brunetau (1932, *Rev. Zool. agric.* 31 : 9), and may be translated as follows: "In the commune of Bors de Baignes quantities of larvae devastated about a hectare of buckwheat, leaving only the stalks and reducing the plantation to skeletons. Lacking food the ravagers descended to the ground in millions, and moved off browsing on *Rumex* by the way, until they reached a plantation of cabbages. Some of them climbed on to these plants, but they were soon abandoned, and at last they reached a vineyard, which they began to misuse. Parts recently sulphated

were respected, but the young growth, the leaves where the Bordeaux mixture was less apparent and even the twigs were damaged."

Celerio livornica in Britain.

Whatever may be the stimulus which releases the migratory impulse, it is very strong when once aroused. If Africa be the source of the majority of specimens of *livornica* caught in Great Britain in spring, a fact which there is little reason to doubt, journeys of a thousand miles or more must frequently have



been flown. Great Britain has been reached in at least seventy-two of the 113 years since the species was first found here (fig. 1), and although in most of these years only one or two individuals have been seen, there have been occasions when comparatively large numbers must have been present. In 1870, for example, at least seventy moths and larvae were recorded; in 1906 the numbers reached one hundred and in 1931 over one hundred and fifty individuals were seen, among them both adults and larvae. It should not be thought that these rising figures represent an actual increase in the numbers reaching Britain; they are much more likely to indicate the larger number of persons taking an interest in the matter. But it is reasonable to suppose that fig. 1 does give a more or less true picture of the relative abundance and scarcity in various years. It is unlikely, for example, that the number of observers decreased materially

Celerio Livornica in Britain—(Larvae in Brackish)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul	Aug	Sep	Oct.	Nov	Dec.	No. date	Years total
1823													1	1
24							1							1
27													1	1
28													2	2
1830													1	1
31								1						1
32								1						3-(2)
34									5-(2)					4
1844							4						4	
46							9	1	2				4	16
47													1	1
1856													3	
57							1	1	1				3	3
58													2	2
59													3	2
1860							18	1	6				3	28
61	1	1											1	2
62		1	3	6	1								1	12
63					1								1	1
64													2	2
65													1	4
66							2		1				3-(1)	5-(1)
67							8	1					3	14
68							1	2	20	2			4	29
69							3		1				3	7
1870							11	12	1-(40)	11	7	1	6-(40)	50-(20)
71													1	1
72							1		1				1	3
74							1						1	1
75							1						1	2
76													2	2
77							1		1				2	2
78							5	1	3				3	9
79							4						4	4
1880										2			1	3
93							2	4					2	
94							1	2		1			5	5
95													1	1
96													2	8
97													2	2
98													1	1
1890								6					2	
91										1			1	
92							1	5					1	7
93							2						2	
94							8	1					3	
95							1	1	1	1			3	
96							3	1	1	1			6	
97							1	1		1			1	4
98							3		1				4	4
1900							2	1	2				1	6
1							1		1				2	
2									(1)				1	1-(1)
3													1	
4							7	31	3	(1)	1	4		39-(1)
5							19	69	1-(1)	2	6		2	10
6							1		1				2	99-(1)
9							1		1		1		3	
1911													1	7
12	1	1					41	2		1			2	44
13													3	
15								1					1	
1920							14	(1)	1					1-(1)
22							5		(1)				1-(1)	6-(2)
24							1		1				2	
25							1						1	1-(1)
28							1	1	1	(1)	2		5	
1930										2			2	
31							31	100	1-(16)	(12)	1		9	142-(23)
32							2	(5)					5	2-(6)
33								(6)	2	1			2	5-(6)
35							1	1		1			5	
Adults	2	2	2	25	209	240	34	50	36	4	2	0	87	693
Larvae							1	43	13				12	69

from 1906 to 1907, yet the number of *livornica* recorded fell from one hundred to nil; again, from 1931 to 1934 the number of observers reporting the presence of migrants to the Insect Immigration Committee rose steadily, yet records of *livornica* fell from more than 150 in 1931 to 12 in 1932, 11 in 1933, and none in 1934.

Fig. 2 shows the seasonal distribution of all the individuals shown in fig. 1, with the addition of larvae, the numbers of which are given in brackets. In some cases, the date of capture, apart from the year, is not known; such insects are shown in the column before the year's total.

It will be seen that the species has been found in every month of the year except December; May and June being those in which it is most numerous. Larvae are more common than adults in July, and the subsequent increase in the number of adults in August and September may be taken as evidence of the emergence of a British-born generation. An interesting comparison may be made between *livornica* and those migrants which, like *Vanessa atalanta*, *Vanessa cardui*, *Plusia gamma*, etc., visit this country every year in fairly large numbers. In these cases the autumn emergences are almost invariably far more numerous than the spring arrivals, showing that our summer conditions are suitable, and that it is only inability to pass the winter here that prevents the species from gaining a permanent foothold. In *livornica*, on the other hand, the autumn generation is rarer than that of early summer; our conditions must be unfavourable to the species even at the best time of year, and even should they succeed in passing a winter or two, they must die out in time unless reinforced by fresh migrants from the south.

The number of moths found in Great Britain from November to March is over 1% of the total, a surprisingly large amount. If *V. atalanta* were found in similar proportions, for example, many hundreds would be seen here every winter. While most of those found in April may be early immigrants (the species is active in Mediterranean districts in March) the occurrence of even single specimens in January and February suggests that hibernation is not entirely impossible, even if it be infrequent. The experience of those who have reared the species in captivity shows that the pupal stage is short, the moths emerging three or four weeks after pupation. There is no account of the finding of the pupa in winter in this country, or, indeed, anywhere else in Europe.

The occurrence of these unusually early individuals does not necessarily either precede or follow years of abundance; indeed, in one case a February specimen was caught during a period when the species was almost absent from Europe. This moth was shown at a meeting of the South London Entomological Society in 1887, and there can be no question of its correct identification. The account of its capture given by Mr. J. A. Helps (1887, *Entomologist*, 20 : 157) is so interesting that it is worth quoting here in full.

“ On April 18th last an old servant, living with her father at Coles Cross, near Crewkerne, sent me a specimen of *Deilephila livornica*, which flew into their cottage (attracted by the light) in the beginning of February last. She states that they caught one last year, and that a neighbour took one the previous year, about the same date.”

Apart from this one specimen (the other two mentioned in Mr. Helps' letter were not included in figs. 1 & 2, owing to lack of reliable identification) I have been able to trace no other record of *livornica* in 1887 in the whole of Europe, and only one in 1886, a single individual in Hesse, Germany.

The sex is recorded in eighty-five of the *C. l. livornica* found in Great Britain,

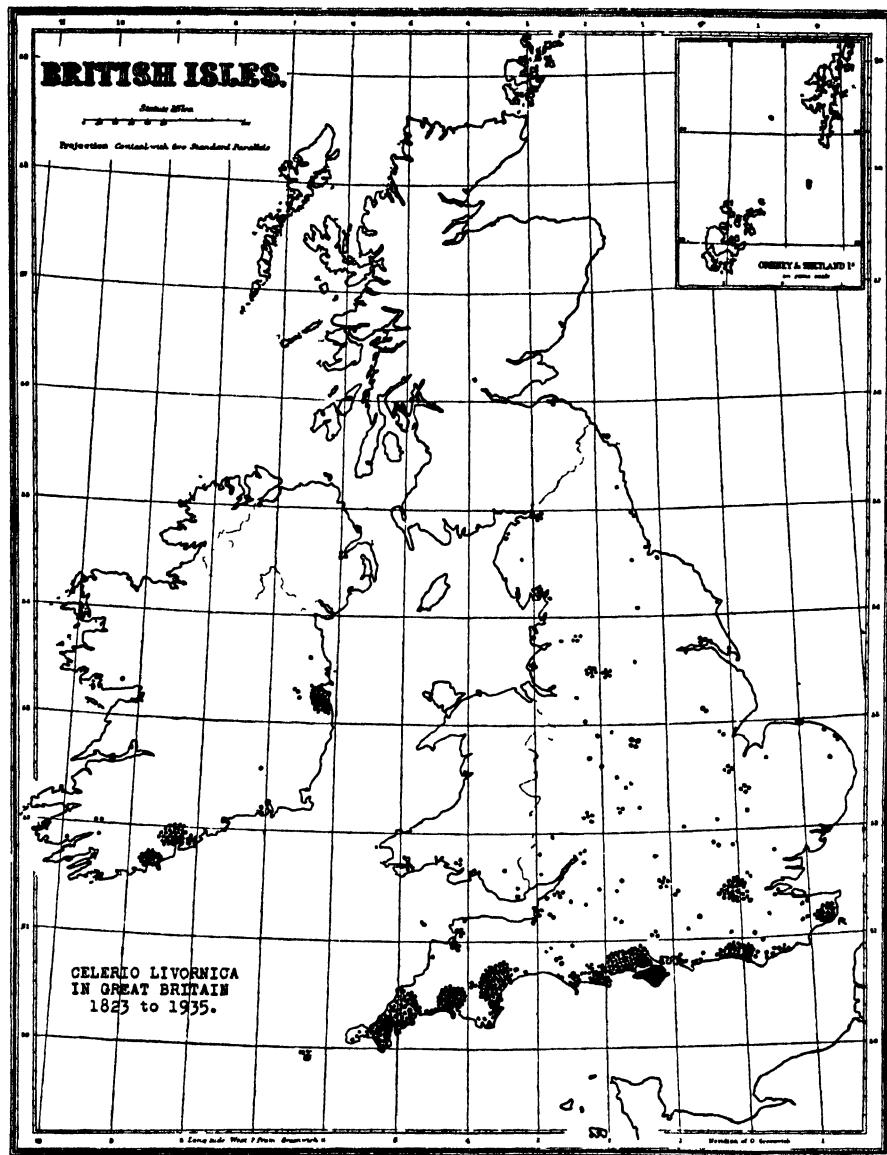
the proportions being fairly near to equality, i.e. forty males to forty-five females. Comparatively few of the continental specimens have been sexed, and in these the females outnumber the males by thirty-three to six. Part at least of the preponderance of females may be accounted for on the assumption that many individuals were only sexed at all as a result of their laying eggs, the sex in other cases being ignored. Nevertheless, there is some reason to suppose that the species is one in which the females normally outnumber the males. On one or two occasions, small numbers of imagines have been reared from eggs laid by captive females, and the sex of all the resulting moths has been recorded. In one such experiment, thirteen eggs gave rise to nine adults, eight of which were females, and in another an equal number of eggs gave rise to two males and four females. More information is needed on this point, and it is hoped that when next the species appears in quantity, observers will be careful to determine the sex in as many cases as possible.

The map in fig. 3 has been drawn to show the distribution of all *C. l. livornica* seen in Great Britain between 1823 and 1935, both adults and larvae, except for a few specimens whose locality I have been unable to trace. A separate map was originally drawn for the moths seen in late summer and autumn; it was thought that this might show a breeding area smaller than that reached by immigrants. This was not so, however; the two maps were essentially similar, and were eventually combined to form fig. 3, which now shows the location of all records, irrespective of season.

Naturally such a map is influenced by the distribution of human population. The large empty spaces shown in such areas as central Ireland and the mountains of Wales, where there are few people and fewer entomologists, probably received their quota of moths like other places, but the insects arrived unobserved and passed unseen. In estimating the local abundance of insects, however, there is one clue which does not depend on human population, and which may be used as a rough guide to relative numbers in different places. This is the number of insects seen by each individual observer. If this correction be applied to the present map, it is found that it only intensifies the tendencies that are already apparent. In the Midlands and North, the appearances are almost invariably solitary, and at intervals of many years. Along the south coast, the species occurs more frequently, and the same observer sometimes reports two or three individuals in a single year. But the greatest numbers are found in the extreme south-west and in Ireland. From Cornwall are records of as many as twenty-five specimens taken by a single collector in one year, while in Ireland, twenty-one *l. livornica* were seen at Timoleague, Co. Cork, in 1931, and thirty-two were reported from Shankhill, Co. Dublin, in the same year, by single observers in each case.

This tendency to greater abundance in the west is found in other migrants besides *l. livornica*, and gives rise to some interesting speculations. A glance at the map of Europe shows that if a migration leaves the western part of north Africa travelling northwards, after it passes Lat. 44° a part of it will have to cross the plains of France, and a part the Bay of Biscay. It is reasonable to suppose that the section flying over France will gradually thin out as it goes northwards, many individuals ceasing their migration and settling in France long before the Channel is reached. Those farther westward, however, will find themselves crossing the open sea, and will be unable to stop until they reach Cornwall, Ireland, or the shores of the Irish Channel. They will thus arrive with their numbers unimpaired, except by the loss of such individuals as have fallen into the sea and been drowned.

There is very little evidence of insects actually seen crossing the Bay of Biscay; one or two records do exist, however, and the arrival of butterflies in the Scilly Islands, where they are reported flying northwards in from the sea,



suggests that it is not impossible for them to do so. It may be objected that the four hundred miles from Spain is an unlikely distance for insects to fly at a single stretch, and that most individuals attempting to do so must inevitably perish, but it seems likely that migrating insects may be able to refresh themselves by floating for a while on the surface of the water. Miss

Longfield told me that she has seen a hawkmoth alight on the surface of a pool in Ireland, and rise from it again, and the keepers of lightships have on several occasions reported similar behaviour on the part of migrating Pierids. If this ability to rest on the water is at all normal, it must be of great assistance to Lepidoptera making long sea crossings.

C. l. livornica in Europe and *C. l. lineata* in America.

Celerio livornica was first described by Petiver from a specimen caught as long ago as 1698 in Lisbon (1764, *Gazophylacium* 1 : 2, Tab. XL, Fig. 11).

The description is of the vaguest, but luckily the moth is figured well enough for identification. During the next century a few solitary adults of both subspecies were captured and described, and one or two larvae were found in vineyards. The first mention of large numbers occurs in 1818, when the species was plentiful in Switzerland especially round Berne (Meisner, 1818, *Nat. Anz.* 1 : 44). The moths were common in the Caucasus in 1829, and a single individual, probably on migration, was seen at a height of 12,000 feet on Mount

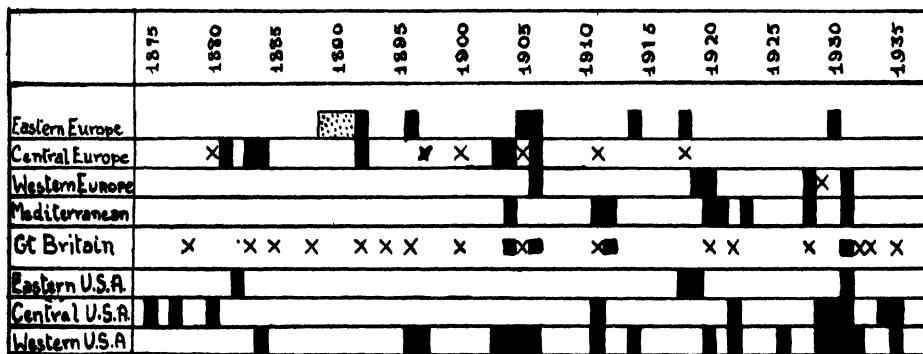


FIG. 4.—Comparison of outbreaks of *C. l. livornica* in Europe and *C. l. lineata* in America.

Elburz. In 1835 a migration arrived at Montpellier, on the south coast of France, after violent southerly winds; it is difficult to decide from the description whether the observer actually saw the moths coming in from the sea, but they were at any rate suddenly abundant all along the sea front.

In 1846 numbers appeared in Germany, and extended westwards as far as Great Britain, where twenty-six individuals were recorded. Twelve years later an outbreak in the Alburns (Elburz?) Mountains, near the Caspian, had no counterpart in western Europe, and in 1864 the moths were again common in Asia Minor, but not unusually so elsewhere. Western Europe was next visited in 1870, and on this occasion the greater number of records came from Great Britain; in 1874, the species was unusually abundant in Algiers, and present (numbers unspecified) in Persia. Outbreaks after this date are recorded in fig. 4, and need not be listed further in the text. That of 1883 is perhaps worth special reference, since in this year the moths were extraordinarily abundant all over central Europe, but apparently nowhere else.

It seems extraordinary that no mention of the damage done by the larvae should be made in European literature until 1904, although *C. lineata* had been recognised for some time in America as an occasionally severe pest of vines. The damage done, however, is very sporadic and local, and it was not until well into the nineteenth century that entomologists began to take an interest in the

practical aspects of their science; even then they largely confined themselves to the more important pests. It is probable that outbreaks occurred from time to time in Europe, but no one took any notice of them except the unfortunate farmers whose crops were attacked. Once attention was attracted to it, *l. livornica* was found to infest a great number of wild and domesticated plants. In cultivation, the most important host is the vine, and when the larvae are present in large numbers they will strip the plants very quickly, devouring even shoots and young grapes. Other plants besides vines are sometimes attacked; among them are olives (Tunis, 1904); cotton (Spain, 1928); buckwheat (Caucasus 1930 and France 1931). In addition to these hosts, the American sub-species has also been reported from tobacco (Jamaica, 1922).

Fig. 4 has been prepared to show in the form of a graph all outbreaks that have been traced in Europe and North America since 1875, the year when the first American outbreak was recorded. Particulars of most of these American outbreaks were sent me by the United States Department of Agriculture, but some half dozen additional records were obtained from various journals. The black areas in the graph represent years in which definite outbreaks occurred; the shaded area in eastern Europe for the years 1889–1891 represents a period when the species was certainly present in Rumania, but its numbers were recorded in such vague terms that it is impossible to say whether there was anything comparable with the outbreaks recorded in other places or not. The crosses represent the occurrence of the species in numbers which, although small, were unusually high for the latitude concerned; they may possibly have been connected with outbreaks farther south which passed unnoticed. The most surprising fact brought out by this figure is the degree of correspondence between years of outbreak in America and those in Europe; of the sixty years that have passed since the first outbreak was reported from America, there has been correspondence in forty years and dissimilarity in only twenty. The following table will make this clear :

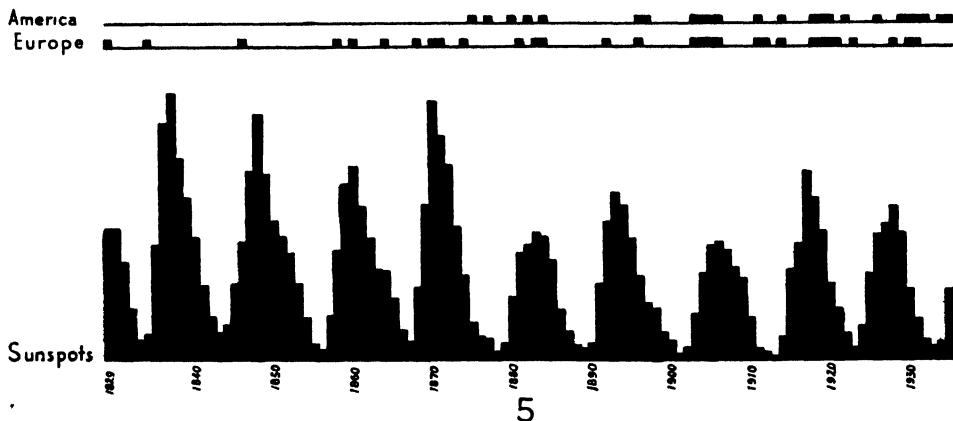
Outbreaks in both continents : 13	In America only : 10	In America : 23
In Europe only : 10	In neither : 27	Not in America : 37
In Europe : 23	Not in Europe : 37	Total : 60

Thus, of the twenty-three years when there were outbreaks in Europe, only ten years were without an outbreak in America; in the thirty-seven years when there were no outbreaks in Europe, they occurred only ten times in America. If the three doubtful years mentioned above, 1889, 1890, and 1891 be counted as years when no outbreak occurred, the correspondence becomes stronger, with forty-three years in which the continents resembled one another, and only seventeen in which they differed. It is most unlikely that figures such as these should be due to accident, the chances against it being about twenty-two to one if the three doubtful years in Rumania are counted as outbreaks, and greater than a hundred to one if they are not. It will be seen that the crosses representing small numbers in unlikely places tend to strengthen the correlation between Europe and America rather than to weaken it.

The implication of all this is clear. In seeking for an explanation of the

outbreaks of *l. livornica* and *l. lineata*, one must look for some large cause, wide enough in its effects to have influenced both continents simultaneously. One or two authors have, for example, put forward the suggestion that forest fires or the passing of locusts or grasshoppers may have caused the multiplication of the moths, by cutting back the larger trees and shrubs, and so encouraging the growth of the lower plants on which the larvae feed. But this will not satisfy the new requirements, since a forest fire in America will not benefit *l. livornica* in north Africa, neither can the incidence of African locusts have much effect on *l. lineata* of America. Incidentally, it has yet to be shown that either sub-species ever occurs in forests, or near enough to them to gain by their temporary destruction.

A possible explanation of the coincidence between outbreaks of sub-species in two continents would be that both were subject to a periodicity of the same length, and that the periodicities were in phase with one another. A glance at figs. 1 and 4 will show, however, that there is no regular periodicity.



An example of a somewhat irregular periodicity to which much has been attributed in recent years lies to hand in the sunspot cycle. Sunspot activity can be measured by counting the number of spots each year, and the figures of such counts are available for the whole period covered by the work on *l. livornica*. The number of spots varies from none (1810) to 137 (1837); more general minima being 3 to 5, and maxima 80 to 90. The maxima occur on an average every eleven years, after which there is a fairly gradual fall towards the minimum, followed by a more rapid rise to the next maximum.

There does seem to be some relationship between the outbreaks and sunspot cycle, as shown in fig. 5, which may be expressed in tabular form as follows :

		Total.	Minimum to Maximum.	Maximum.	Maximum to Minimum.	Minimum.
Years		107	32	11	54	10
Outbreaks	To be expected in absence of correlation . . .	—	12.3	4.2	20.7	3.8
	Observed . . .	41	14	6	20	1
	Difference . .	—	+ 1.7	+ 1.8	— 0.7	— 2.8

There have been forty-one outbreaks in the past 107 years, and if there were no connection between outbreaks and sunspots, this proportion should be preserved throughout. The figures predictable on this basis are given in the second line of the table, and in the fourth line the difference is shown between these figures and the actual outbreaks recorded. The number of outbreaks would seem to rise from the minimum towards the maximum, and then to fall away again towards the next minimum, the difference between predicted and observed values being greatest at the year of minimum activity, where the figures are just significant. But the possibility of the apparent connection being due to chance is not precluded; it is worthy of note that some of the most recent and widespread outbreaks (1930-1932) have taken place during a period of rapidly falling activity.

Reference has been made earlier to the possibility of climate influencing the outbreaks of this moth, and rainfall immediately comes to mind as the factor most likely to be effective. While rain is usually supposed to be absent

	Nevada		Utah		Arizona		Colorado		NEW MEXICO	Total Plus or Minus	Wet or Dry	lineata outbreaks	
	Battle	Tonopah	Fallon	Moab	Salt Lake	Yuma	Phoenix	Colorado					
	City							Springs	Ames	College	+	-	
1901	-	+	+	+	+	+	+	-	+	+	8	3	W
6	+	+	-	-	-	+	-	+	-	-	5	6	D
9	+	-	-	+	+	+	+	-	+	-	8	3	W
1910	+	+	+	+	+	-	-	+	-	-	7	4	W
11	+	+	-	-	-	+	-	-	-	-	4	7	D
12	+	-	-	-	+	-	-	+	-	-	4	7	D
13	-	+	+	+	+	-	-	-	-	-	5	6	D
14	+	+	+	+	+	+	-	+	+	+	9	2	W
15	+	+	+	+	+	-	+	+	+	+	10	1	W
16	-	+	+	+	+	-	+	+	+	-	7	4	W
17	-	+	-	+	+	-	+	-	+	-	6	5	W
18	-	-	-	-	-	-	-	-	-	-	11	D	X
19	-	+	+	-	+	-	-	+	-	+	6	3	W
1920	-	-	-	-	-	+	+	-	+	-	4	7	D
1	-	+	+	+	-	+	+	-	-	-	5	6	D
2	+	+	+	+	+	+	+	-	+	-	9	2	D
3	-	-	+	+	+	-	-	-	-	-	3	8	D
4	+	-	-	-	-	+	+	+	+	+	6	5	W
5	-	+	+	-	-	-	-	-	-	-	1	10	D
6	+	+	+	+	+	+	+	-	+	+	10	1	W

FIG. 6.

from deserts, it is not entirely unknown, especially on their outskirts, and when it does fall its effects are proportionately great. Unfortunately, very few figures seem to be available for the Old World deserts; it would seem that either there are no weather stations in the Sahara, or else that a rain gauge is not considered a proper part of their equipment. By courtesy of the London Meteorological Office, I have been able to obtain a few figures; most of them come from Egypt, but one or two series are from stations near to the more westerly part of the Sahara, and one is from Tiflis, in Asia Minor; most of the series are comparatively short and much broken. There does not seem to be any correlation between them and the outbreaks of *I. livornica*, but the figures are far too scanty for it to be said with certainty that no correlation exists.

From America, the United States Department of Agriculture Weather Bureau have sent me copies of their climatic summaries for the relevant States. Many of these summaries go back before 1875, the year of the first recorded *I. lineata* outbreak, and from them it has been possible to compile a table showing the departures from the annual mean rainfall in eleven scattered desert States. A portion of this table is illustrated in fig. 6. Since outbreaks tend to occur about June, the year's rainfall has been calculated from June to May, instead of from January to December, the more usual method. Where the stations showing a deficiency in any year outnumber those showing an excess,

it is counted a dry year; where the reverse occurs, it is counted wet. This gives a rough criterion by means of which it is possible to divide the period into years of relatively high and relatively low rainfall, as a basis for comparison with years when outbreaks of *lineata* occurred. The direct comparison of years of outbreak with the rainfall of the previous twelve months does not give a very promising result. There is a slight tendency for outbreaks to follow wet years, but the figures are not significant, and no conclusions can be drawn from them. If, however, the weather for two years preceding the outbreaks be taken into consideration the very interesting result is found that there is a distinct tendency for outbreaks to occur when a wet year has followed a dry year. These results may be summarised as follows :

		Total.	Dry years following dry years.	Dry years following wet years.	Wet years following wet years.	Wet years following dry years.
Years	.	60	22	13	11	14
Outbreaks	To be expected in absence of correlation	—	—	—	—	—
	Observed	23	8	3	2	10
	Difference	—	— 0·4	— 2·0	— 2·2	+ 4·6

Here, the observed values are below those predicted in every column except the last, where wet years following dry years are shown. The figures are significant, and the chances against them having occurred by accident in this particular proportion are about forty-five to one. The interpretation of these results is by no means easy; indeed, it is difficult to make even an intelligent guess to account for the connection between this particular sequence of weather conditions and the subsequent migrations. One might imagine that the dry year forced the insects out to the edges of the desert area, and that if subsequent wet weather should stimulate breeding and produce over-population, the moths would migrate outwards to cultivated lands as well as inwards towards the desert again. But this is to indulge in pure speculation; the interesting point is that these figures do strengthen the suggestion that *C. lineata*, at least, is a species of desert or semi-desert origin. It is a great pity that the paucity of weather records do not permit us to check it by comparison with the African sub-species.

Acknowledgments.

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In particular my gratitude is due to Mr. W. G. Cochran, of the Rothamsted Statistical Department, for the patience with which he has helped me with the statistical parts of this paper.

References.

During the course of the work, about two thousand volumes have been consulted, and nearly a thousand abstracts have been made. To give a complete list of sources would involve many pages of print, and would probably be of very little practical value. A full index of references is preserved at the Rothamsted Experimental Station, where they may be consulted by anyone interested in the subject.

The chief publications studied were :

The Entomologist.

The Entomologist's Monthly Magazine.

Annales and Bulletin de la Société Entomologique de France.

Annals and Magazine of Natural History.

The Zoologist.

The Review of Applied Entomology.

Horae Societatis Entomologicae Rossicae.

Boletin de la Sociedad Entomológica de España.

Stettiner Entomologische Zeitung.

When an adequate index was present, such publications were taken volume by volume from their commencement. Many, however, had only lists of titles, and in these the method used was to pick a promising title, read the article concerned, and follow up any reference that might be given. A good deal of information was probably lost in this way, but the only alternative was page-to-page search, an impossibly lengthy task. Innumerable local lists of Lepidoptera for all parts of Europe were consulted, and some references were found in standard works, such as Tutt's *British Lepidoptera*, etc. Wherever possible such references were traced to their original sources, but this could not always be done, especially in the case of some of the earlier Russian writers. Some of the sources seem to have been privately circulated local lists in manuscript, and others I have been unable to trace at all.

Summary.

The distribution and outbreaks of the sub-species *Celerio lineata lineata* Fab. in America, and *Celerio lineata livornica* Esp. in the Old World as far as they are known are described. It is suggested that both sub-species originate in semi-desert areas, and this idea is supported in the case of the American sub-species by showing that a correlation exists between outbreaks of the moths and a certain sequence of desert rainfall. No correlation is found between European outbreaks and the rainfall of those North African meteorological stations for which records are available, but this may be due to the paucity of suitable figures.

A full account is given of the occurrence of *C. l. livornica* in Great Britain, and the main European outbreaks are listed. A correlation is given to show that both years of unusual abundance and of absence tend to occur simultaneously in Europe and America, and that the cause of outbreaks must therefore be sought in some factor common to the two continents.

There seems to be some correlation between outbreaks and the sunspot cycle, but the figures are barely significant. The outbreaks tend to occur away from the sunspot minima.

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